DOCUMENT RESUME

ED 220 332 SE 039 094

AUTHOR	Agro, Sally; And Others
TITLE	Measuring. USMES Intermediate "How To" Set.
INSTITUTION	Education Development Center, Inc., Newton, Mass.; Unified Science and Mathematics for Elementary Schools, Newton, Mass.
SPONS AGENCY	National Science Foundation, Washington, D.C.
REPORT NO	ISBN-0-89292-030-0
PUB DATE	77
GRANT	SED-69-01071
NOTE	73p.; For related documents see SE 039 060-098, ED 142 362, and ED 183 367.
AVAILABLE FROM	ERIC Clearinghouse for Science, Mathematics, and Environmental Education, 1200 Chambers Rd., 3rd Floor, Columbus, OH 43212 ($3.25).
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	*Elementary School Mathematics; *Elementary School Science; Instructional Materials; Interdisciplinary Approach; Intermediate Grades; Language Arts; Learning Activities; Mathematics Education; *Measurement; *Measurement Equipment; *Problem Solving; Process Education; Science Course Improvement Projects; Science Education; Social Studies; *Unified Studies Curriculum
IDENTIFIERS	National Science Foundation; *Unified Science Mathematics for Elementary Schools

ABSTRACT

In this set of five booklets on measuring, intermediate grade students learn how to use a stopwatch, choose the right tool to measure distance, use a trundle wheel, make a scale drawing, and find the speed of things. The major emphasis in all Unified Sciences and Mathematics for Elementary Schools (USMES) units is on open-ended, long-range investigations of real problems. In most instances students learn through observing results of their own and their classmates' experiments. However, students may recognize the need for certain facts and/or skills during their investigations. Although some children prefer to work things out for themselves, others may ask for help. USMES "How To Sets" are designed to provide such assistance. Each booklet in a set contains several examples of children using a skill being taught, each example emphasizing a different aspect of the skill or a potential pitfall. The first page tells why or when a student may need the skill covered in the booklet and includes a table of contents. There is no sequence to the sets (or booklets within sets) and they should not be used out of the context of childrens' open investigation of a practical problem. (Author/JN)

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USMES INTERMEDIATE
UNIFIED SCIENCES AND MATHEMATICS FOR ELEMENTARY SCHOOLS

HOW TO SET

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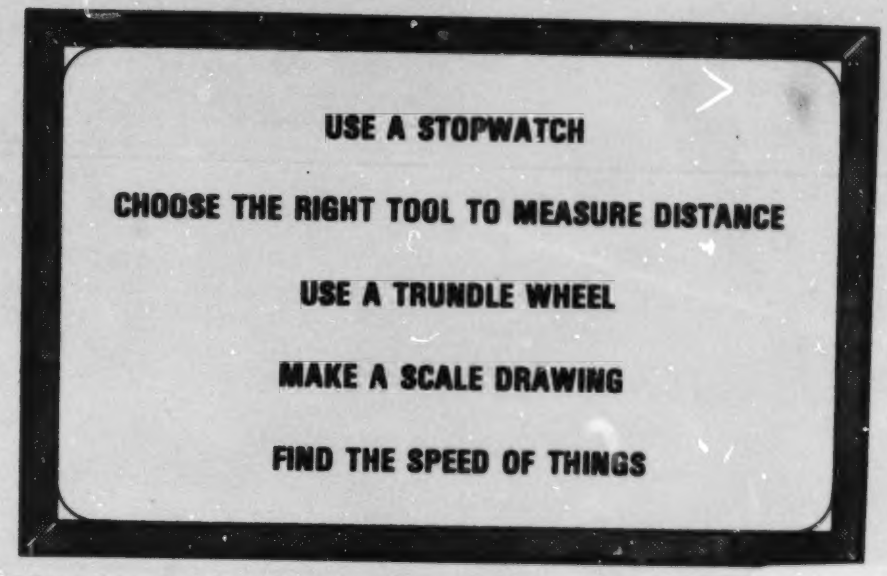
USE A STOPWATCH
CHOOSE THE RIGHT TOOL TO MEASURE DISTANCE
USE A TRUNDLE WHEEL
MAKE A SCALE DRAWING
FIND THE SPEED OF THINGS

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MEASURING

SE 039 094

WHAT IS USMES?

USMES challenges students to solve real problems within their school and community. Students tackle problems like a busy or unsafe intersection near their school, classroom furniture that doesn't fit them, or playgrounds that are crowded or uninteresting. These problems have immediate and practical impact on students. They have no established, correct solutions--students take or recommend action based upon whatever data they collect and analyze. Furthermore, the students themselves, not the teacher, direct the problem-solving process.

Solving real problems is interdisciplinary: skills, processes, and concepts from science, mathematics, social science, and language arts all play a part. For example, students conduct opinion surveys, build measuring devices, write letters, and make and use graphs. They also make decisions, work productively in small groups, and develop and clarify values.

The USMES curriculum is organized into twenty-six problems, or units, that have been developed in the classroom by teachers and students in a wide variety of schools. Most units can be used in grades K-8 although the level at which students approach a problem and develop a solution will vary according to age, ability, and interest.

RESOURCES FOR AN USMES PROGRAM

In addition to the USMES "How To" Series, there are--

The USMES Guide: This book describes the USMES project, real problem solving, classroom strategies, the Design Lab, the units, and the support materials as well as ways that USMES helps students learn basic skills. A section in the guide correlates the twenty-six USMES units with topics in Science, Mathematics, Social Science, Language Arts, Career Education, and Consumer Education.

Teacher Resource Books (one per unit): Each of these guides to using USMES units describes a broad problem, explains how students might narrow that problem to meet their particular needs, recommends classroom strategies, and presents logs from teachers whose classes have worked on the unit.

Design Lab Manual: This guide helps teachers and administrators set up, run, and use a Design Lab--a place with tools and materials where students can build things they need for their work on USMES units. A Design Lab may be a corner of a classroom, a portable cart, or a separate room.

Background Papers: These papers provide teachers with information and hints that do not appear in the student materials.

The "How To" Series is a resource developed by the USMES project. Earle L. Lomon, Project Director, Betty M. Beck, Associate Director for Development, Thomas L. Brown, Associate Director for Utilization Studies, Quentin E. Baker, Associate Director for Administration.

This material is based upon research supported by the National Science Foundation under Grant No. SED 69-01071. Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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Complete USMES Library ISBN 0-89292-033-5
Intermediate "How To" Series ISBN 0-89292-030-0

THE USMES INTERMEDIATE *HOW TO* SERIES

USMES and Skills

USMES students often see a need to learn new skills to help them get a problem-solving job done. Students seeking to improve a street crossing may want to learn how to use a stopwatch or how to make a trundle wheel. Students comparing different brands of paper towels may want to learn how to design an experiment and how to make a bar graph. The list can go on and on, but the pattern is clear; solving a real problem requires skills.

Purpose of 'How To' Series

Materials that help students learn skills like designing an opinion survey and choosing the appropriate measuring tool are not readily available for intermediate grade students. The USMES Intermediate "How To" Series fills this gap. Its magazine-style format helps students acquire the skills and knowledge they need to do things like redesign their classroom, find the best buy in potato chips, or run a school store.

How to Use the 'How To' Series

Wait for a need. When a student asks for help, refer him or her to the appropriate booklet. Having a student read a booklet before there is a need to do so will not only result in less effective learning but will defeat the USMES purpose of allowing students to decide what needs to be done.

When necessary, use the "How To" Series as a teaching aid. Most of the time students will be able to go through a booklet by themselves and learn the skills they need to learn. However, some material in some sets is difficult and somewhat abstract. When the booklet by itself is not doing the job, feel free to step in and help the student go through it.

Knowing how the contents of the booklets are organized may help in using the series effectively.

- The first page tells why or when a student may need the skill covered in the booklet, and includes a table of contents.
- Each booklet contains several examples or stories about students using the skill or process being taught. Each example emphasizes a different aspect of the skill or a potential pitfall.
- When information in other booklets may help the student, the titles of the booklets are included in the text.
- The last pages of each booklet contain a summary of the points covered in the booklet.

OTHER USMES *HOW TO* SERIES

Beginning "How To" Series: This cartoon-style series covers in less detail much of the same material as the Intermediate Series. Its cartoon-style format helps younger children and those with reading difficulties acquire the skills needed to work on a real problem.

Design Lab "How To" Series: These illustrated cards help children learn how to use tools safely and effectively.

"How To" Cards: This series is printed on colored card stock rather than paper. They contain fewer words than the Intermediate "How To" Series and utilize the American system of units (ft./lb./sec.) rather than the metric system. The Collecting Data set, however, is not available in the "How To" Cards.

INTERMEDIATE *HOW TO* SERIES

COLLECTING DATA

Collect Good Data
Round Off Data
Record Data
Do an Experiment
Make an Opinion Survey
Choose a Sample

GRAPHING

Choose Which Graph to Make
Make a Bar Graph
Make a Histogram
Make a Line Graph
Make a Conversion Graph
Use Graphs to Compare Two Sets of Data

MEASURING

Use a Stopwatch
Choose the Right Tool to Measure Distance
Use a Trundle Wheel
Make a Scale Drawing
Find the Speed of Things

SIMPLIFYING DATA

Tell What Your Data Show
Find the Median
Find the Mean
Find the Mode
Find Different Kinds of Ranges
Use Key Numbers to Compare Two Sets of Data

Conceived and Written by:
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Production:
Paula Lakeberg, John Saalfield

edc

"HOW TO"

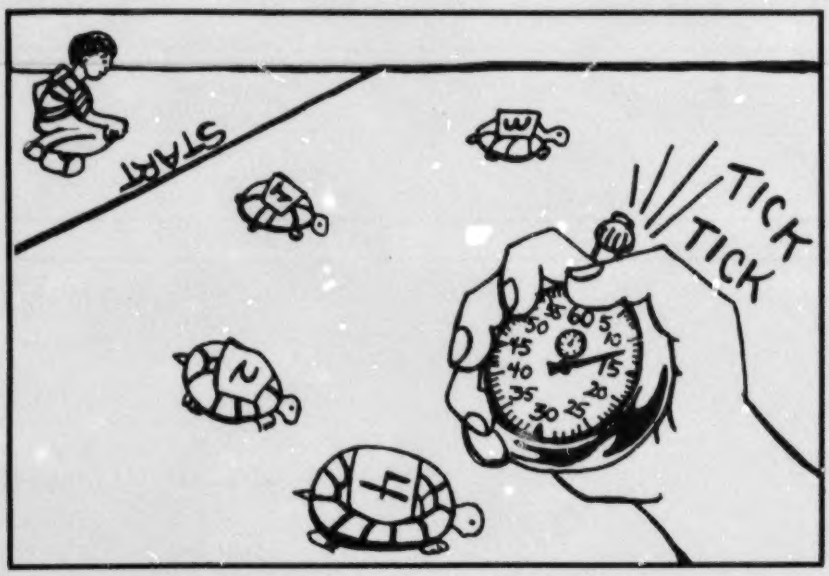
USE A STOPWATCH

Maybe you need to time something. You may need to time a race. You may need to find out how long it takes people to cross a street. Or you may need to keep time during a game.

You can use a stopwatch to time things. It is easier to use than a wrist watch. You can start it and stop it. It is also easier to read.

You can be more exact when you use a stopwatch. A stopwatch measures minutes, seconds, and fractions of seconds.

It helps to know a few things about stopwatches. They are different from wrist watches. Inside, you will find out about stopwatches--how to make them work...how to read them... how to use them for different things...how to get the best results from them.



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IT WILL HELP YOU TO HAVE A STOPWATCH IN YOUR HAND WHILE YOU READ THIS BOOKLET.

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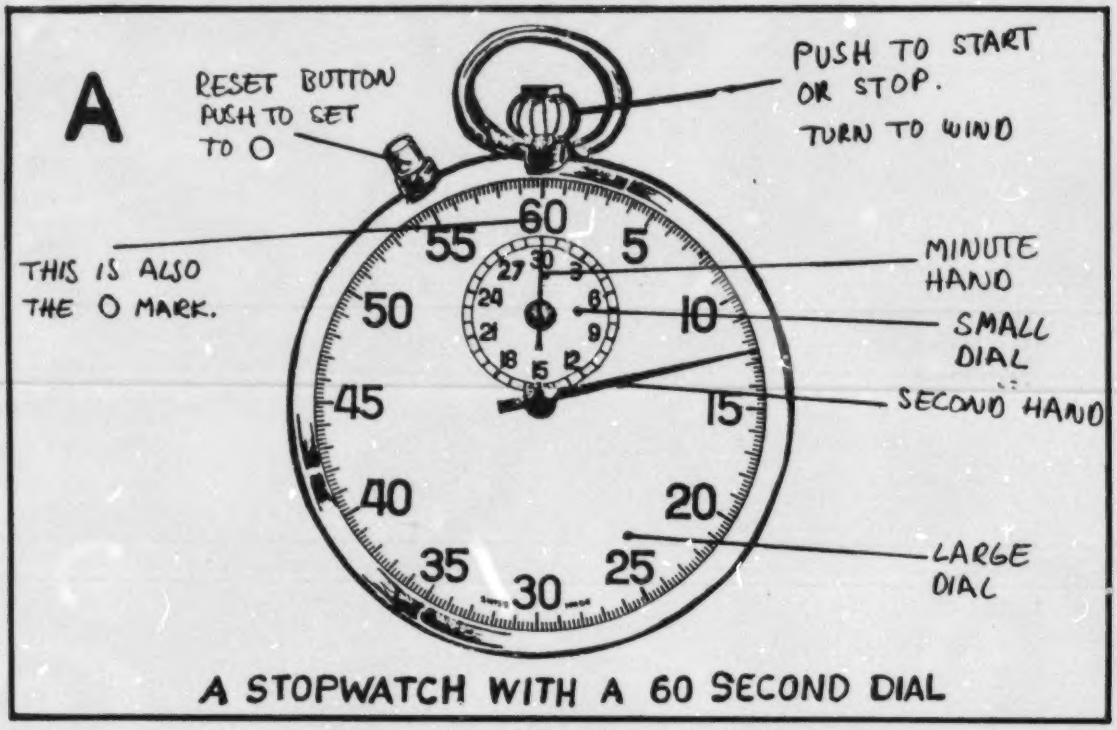
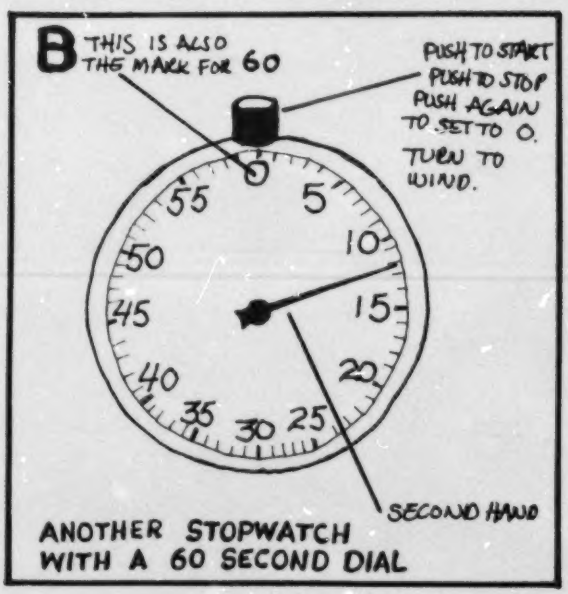
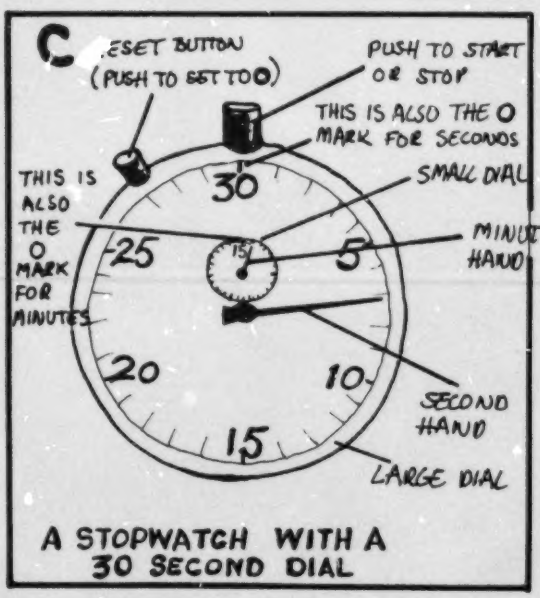
HERE ARE THREE KINDS OF STOPWATCH




B
THIS IS ALSO THE MARK FOR 60
PUSH TO START
PUSH TO STOP
PUSH AGAIN TO SET TO O.
TURN TO WIND.
SECOND HAND
ANOTHER STOPWATCH WITH A 60 SECOND DIAL


C
RESET BUTTON (PUSH TO SET TO O)
PUSH TO START OR STOP
THIS IS ALSO THE O MARK FOR SECONDS
SMALL DIAL
THIS IS ALSO THE O MARK FOR MINUTES
MINUTE HAND
SECOND HAND
LARGE DIAL
A STOPWATCH WITH A 30 SECOND DIAL

Maybe your stopwatch is not like any of these. Then look for instructions that come with the stopwatch. If you cannot find any instructions, try to figure it out yourself, or ask your teacher to help.

USING A STOPWATCH

When you use a stopwatch, follow these five steps.

1. MAKE SURE YOUR STOPWATCH IS WOUND.

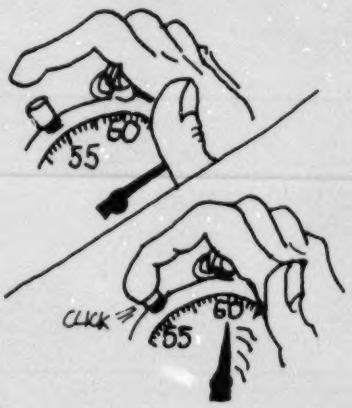
   If your stopwatch is not wound it will not run. Here's how to see if it's wound.

   Turn the button at the top like this. If it does not turn easily, don't force it. It is already wound. If it turns easily, keep turning. This will wind it.

2. RESET YOUR STOPWATCH.

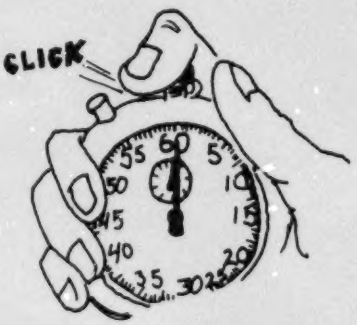
   Are the hands on your stopwatch pointing straight up? If so, you are ready for step 3. If not, push the reset button. This button makes the hands jump back to 0.

   Maybe your stopwatch does not have a reset button on the side. Then you must push the big button at the top. (See drawing B on Page 2.)



3. START YOUR STOPWATCH.

   Push the button on top of the stopwatch. You should hear a click and the hand should start moving.

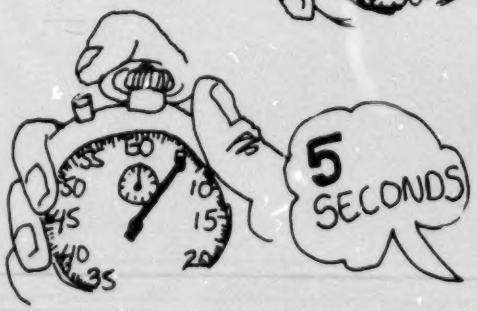


4. STOP YOUR STOPWATCH.

   When you want to stop the stopwatch, push the top button again. You should hear a click and the watch will stop.

5. READ YOUR STOPWATCH.

   The hand on the large dial shows how many seconds have passed. The next two pages tell you how to read your stopwatch.

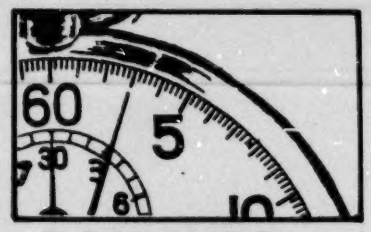


READING A STOPWATCH WITH A 60-SECOND DIAL

READING SECONDS

A 60-second dial has a lot of marks. Not all of the marks on the dial are numbered. The darker marks on the dial stand for seconds. To read how many seconds have passed, look at where the second hand is pointing.

Here are two examples.



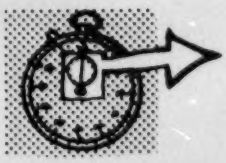
3 SECONDS

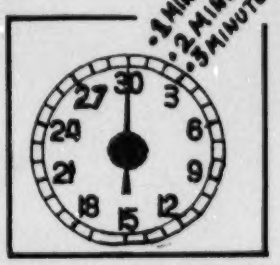
32 SECONDS

READING MINUTES

You may be timing something that takes longer than 60 seconds. If so, you need to use the small dial on your stopwatch.

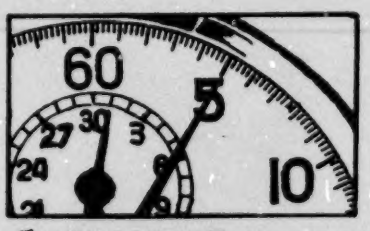
Each mark on this dial stands for a minute.



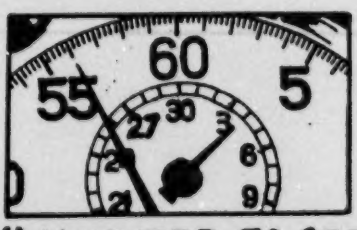


READING MINUTES AND SECONDS

You will probably need to read both minutes and seconds. Here are two examples.



1 MINUTE 5 SECONDS



4 MINUTES 56 SECONDS

Maybe your stopwatch does not have a minute hand. Then you must keep track of minutes yourself. You can keep a tally on a piece of paper. Each time the second hand passes 60 seconds, make a tally mark.

READING FRACTIONS OF SECONDS

Your stopwatch has small marks between the seconds. These marks stand for fractions of seconds. Each small mark on this stopwatch shows 1/5 second. These small marks help you measure time in a more exact way.

Here are two examples.

5 1/5 SECONDS

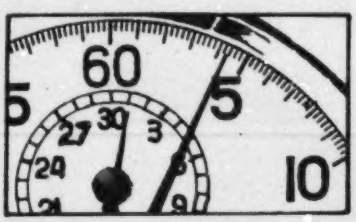
26 4/5 SECONDS

You can also use decimals to show fractions of seconds. For example, 7 1/5 seconds is the same as 7 2/10 seconds and can be written as 7.2 seconds.

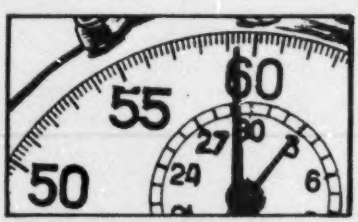
ROUNDING OFF AS YOU READ

You won't always need to measure fractions of seconds.
Are you measuring something that takes a long time? Does it take 30 seconds, or one minute, or several minutes?
If so, don't measure fractions of seconds. Round off your measurement to the nearest second. Read "How To" Round Off Data.

Here are two examples.



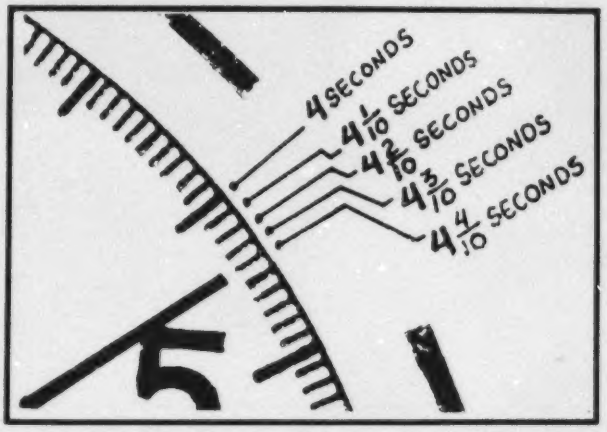
ROUND OFF TO
1 MINUTE
4 SECONDS



ROUND OFF TO
3 MINUTES
59 SECONDS

READING A STOPWATCH WITH A 30-SECOND DIAL

On some stopwatches, once around is 30 seconds instead of 60 seconds. Here's how to read this kind of stopwatch.



READING SECONDS AND FRACTIONS OF SECONDS

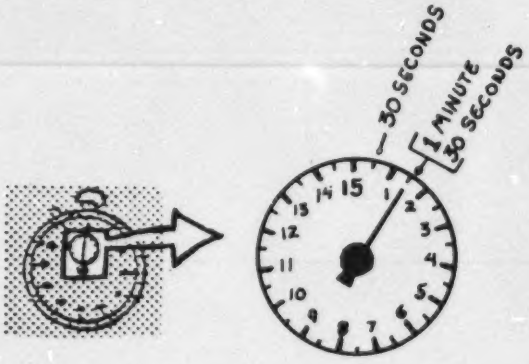
On a 30-second dial, there are more small marks between each second. Each small mark stands for 1/10 second. To read this kind of stopwatch, look at where the second hand is. This stopwatch shows 4 4/10 seconds or 4.4 seconds.

You may want to round off your measurement to the nearest second. The time on this stopwatch would be 4 seconds.

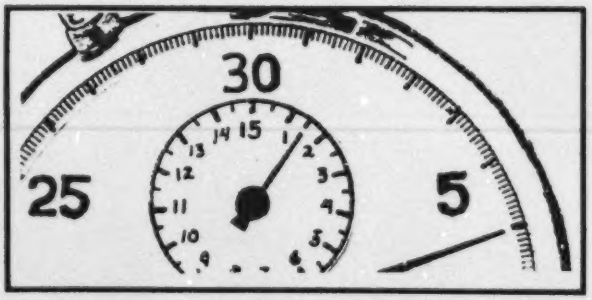
READING MINUTES AND HALF-MINUTES

Maybe you are timing something that takes longer than 30 seconds. Then you need to look at the small dial on your stopwatch. This dial has marks for minutes and half-minutes. A half-minute is 30 seconds.

This stopwatch shows 1 minute, 30 seconds.



When you read the stopwatch, read the small dial. Then read the big dial. Then add. Here's an example.



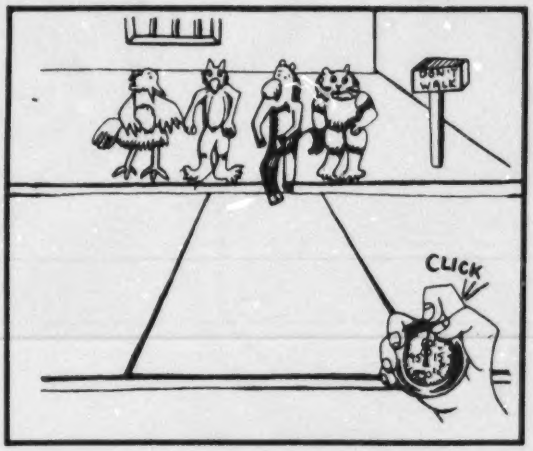
SMALL DIAL:	1 MINUTE	30 SECONDS
BIG DIAL:		6 SECONDS
TOTAL TIME:	1 MINUTE	36 SECONDS

WHEN TO USE A STOPWATCH

You can use a stopwatch in many ways. Here are some of the ways.

YOU CAN USE A STOPWATCH TO MEASURE HOW LONG IT TAKES SOMETHING TO HAPPEN.

You may want to find out how long it takes people to cross a street. Have people walk across one at a time while you time them with a stopwatch. Start the stopwatch when the person begins to cross. Stop it when he reaches the other side. Then read the time it took.

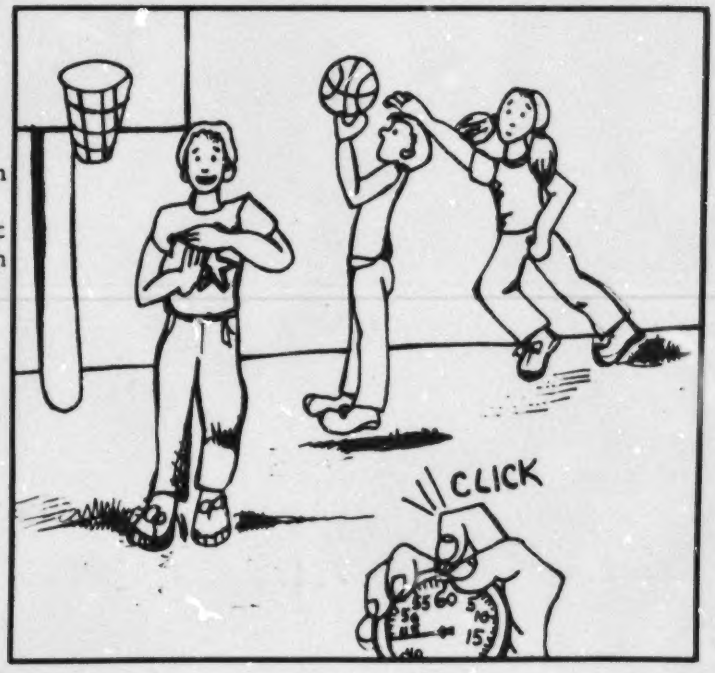


Maybe you need to find out how long it takes someone to find the library or walk the nature trail or go through the lunch line. You can use a stopwatch to time any of these things and many more.

YOU CAN USE A STOPWATCH TO TELL WHEN A CERTAIN AMOUNT OF TIME IS UP.

Suppose you want to give some students a 3-minute test. A stopwatch will make it easy to tell when 3 minutes have passed.

Suppose your class is playing basketball. And suppose you want each game to have 10 minutes of playing time. You can use a stopwatch to keep time. But you don't want to count the time during time-outs or rest periods. When a time-out is called, you can stop the stopwatch. But don't reset it to zero. Then when the time-out is over, start the stopwatch again. This way the stopwatch will be running only when the game is going on.



YOU CAN USE A STOPWATCH TO TIME THINGS THAT ARE HAPPENING ONE AFTER ANOTHER.

You may need to time things that are happening one after another with your stopwatch. Then you will need to read your stopwatch while it is running.

There may be a street that many children cross on their way to school. Suppose you want to find out how much time there is between cars on this street. To do this, you can use a stopwatch.

Start the stopwatch when the first car passes. As the second car passes, look at the time on the stopwatch. Write it down. But don't stop the stopwatch. You must read it while it is running. Read and write down the time when each car passes.

Your data might look like this.

Car Times at Maple and Chestnut Sts. Tues. 10:30 pm.

CAR	TIME (seconds)
1st car	0 (start)
2nd car	10
3rd car	12
4th car	19
5th car	32
6th car	39

To find the time between cars, you subtract. Here's how you would find the time between the 3rd and 4th car.

4th car: 19 seconds
3rd car: − 12 seconds
Time between 3rd and 4th cars: 7 seconds

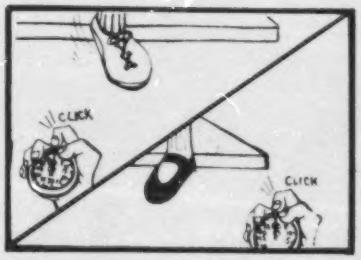
At first you may find it hard to read the stopwatch while it is running. But you can practice and get better. You can also get help from other students. Three students can time cars a lot easier than one. Have one student shout or wave when a car passes. While you read the time aloud from the stopwatch, another student can record the time on a piece of paper.

HOW TO DECIDE WHEN TO START THE STOPWATCH AND WHEN TO STOP IT

You may want to time different people doing the same thing. You may need to time students crossing the street or going through the lunch line or finding their way to the library. You will need to time each person the same way.

1. START TIMING THE SAME WAY FOR EACH MEASUREMENT.

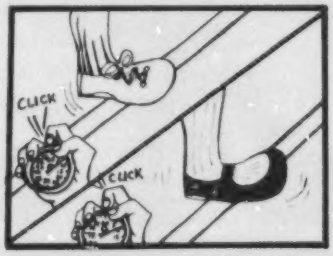
   Suppose you want to time people crossing the street. You will need to decide when to start the stopwatch. You might start it when a person's foot leaves the curb. Start timing the next person the same way. Do it the same way each time.



   You may need to measure how long it takes students to go through the lunch line. Before you begin timing anyone, you need to decide when you will start the stopwatch. You will probably want to start the stopwatch when the person joins the end of the lunch line. Whatever you decide, do it the same way each time.

2. STOP TIMING THE SAME WAY EACH TIME.

   If you are timing people crossing the street, you will also need to decide when to stop the stopwatch. You might stop it when the person's foot touches the curb on the other side of the street. Or when both feet are on the sidewalk. Again, once you decide, do it the same way for each person.



   If you are timing students going through the lunch line, you may want to stop the stopwatch just after the person leaves the cashier. Or just after the person picks up his last food item. Before you time anyone, decide when you will stop the stopwatch.

If you want to know more about how to measure the same way each time, read "How To" Collect Good Data.

HOW CLOSE CAN YOU MEASURE?

ONE KIND OR ERROR: YOUR STOPWATCH IS NOT EXACT

No instrument is exact. When your stopwatch shows a time, it does not mean exactly that time. It means ABOUT that time. It could be a little less. It could be a little more. This error happens even if your stopwatch is working right. The error isn't much, but it makes your measurement less accurate.

ANOTHER KIND OF ERROR: THE WAY YOU MEASURE IS NOT EXACT

Suppose you are timing Jane running a race. You would try to stop the stopwatch exactly when her foot crosses the finish line. But it takes time to press the button. That little extra time will make your measurement less accurate. You may have this kind of error when you start the stopwatch, too. You might even press the button too soon when you stop or start the stopwatch.

WHAT CAN YOU DO ABOUT ERRORS

You cannot avoid these kinds of errors. But there are things you can do to help make up for these errors.

1. *ROUND OFF YOUR MEASUREMENTS AS YOU TAKE THEM.*

   Often your errors will be almost as much as 1 second. Suppose you are timing Cindy as she crosses the street. You try to stop the stopwatch exactly when her foot touches the curb on the other side. But you may have waited 1/5 of a second too long. Or you may have pushed the button too soon.

   You can't tell how much your error is. No matter how much you try, you can't get your measurement exact.

   You can round off your measurements to the nearest second. Most of the time your measurements will be close enough. Read "How To" Round Off Data.

   Sometimes it is better not to round off. Here is an example. Suppose you are timing students running a short dash. Suppose most of their times are 3 or 4 seconds. Those times are very short. It would be better not to round off your data. The times would not be accurate enough if you did.

2. *MAKE SEVERAL MEASUREMENTS AND TAKE THEIR MEDIAN.*

   Sometimes it is easy to make several measurements. Suppose you are timing a WALK light at a street crossing. The WALK light is always on for the same amount of time. You can time it again and again.

Sometimes it is not so easy to make several measurements. Suppose you are timing John as he crosses the street. You may not be able to repeat the measurement. That's because John won't always cross the street in the same amount of time. So how can you get several measurements? You can have a few people timing John all at once. Of course, you will need a few stopwatches.

Mar. 3
WALK Light at Maine and Hampshire
10 seconds
10 seconds
10 seconds

Suppose you have three different measurements of the time John takes to cross the street. You can't tell which one is the best. But you can take the median of the three measurements. "How To" Find the Median will tell you more about this.

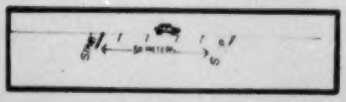
Mar. 6
Time To Cross Maine St.

Student	Time in seconds		
	Jill's	Lee's	Ed's
John	9	10	10

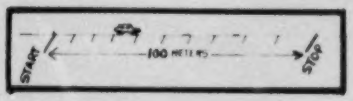
MEDIAN TIME

3. *TRY NOT TO MAKE YOUR TIMES TOO SMALL.*

You can be more exact with longer times than with shorter times. Suppose you are timing cars. Let's say you want to measure how long it takes a car to go 50 meters. Let's say a car takes about 4 seconds. This time is very short. Errors will matter a lot.



What can you do? You can make the time bigger. Instead of timing cars for 50 meters, time them for 100 meters. Then the times will be about 8 seconds. The errors will not matter so much.



4. *SHOW HOW YOU GOT YOUR MEASUREMENT.*

People will want to know how exact your measurements are. The best way to tell them is to say what you did. Write down all all about how you measured and what you did with your data. Then people can see for themselves how exact your measurements are.

Oct. 10
Report of Timing Group
We measured how long it took children to get through the lunch line. We timed every fifth person. We rounded off our measurements to the nearest second. Here are our measurements
Joe K. 32 seconds

"HOW TO"

CHOOSE THE RIGHT TOOL TO MEASURE DISTANCE

DO YOU NEED TO FIND OUT HOW LONG OR HOW TALL SOMETHING IS?

Maybe you want to know how long your gerbil is or how tall your plant is. Maybe you want to know how long your classroom is or how long and wide your desks and tables are. Maybe you want to know someone's waist size or how long your nature trail or bicycle path is.

To find out how long or how tall these things are, you will need to measure a DISTANCE. The distance is how long something is.

WHICH TOOL SHOULD YOU USE FOR YOUR MEASUREMENTS?

There are many tools that you can use to measure a distance. Which tool you use depends on how short or how long the distance is. It depends on whether the distance is along a straight path or along a curved path. It depends on what you want to find out and how close you need to measure.

This booklet will help you to decide which tool is the best to use for your measurements.

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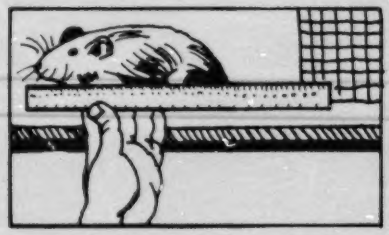
SHORT AND STRAIGHT

Suppose you want to measure a distance that is short and is along a straight line. Perhaps you want to know how tall your plant is or how long your gerbil is. What tool should you use to find out?

You should use a tool that is about the size of your plant or your gerbil. A ruler is about the same length or a little longer than a plant or a gerbil. A ruler is a good tool to use to measure those things.



When you measure your plant or your gerbil, you can measure to the nearest centimeter. You can also measure to the nearest millimeter. You can decide how accurate you have to be.

If you tried to use a meter stick or a tape measure to measure your plant or your gerbil, you would find that they are both awkward and hard to use for such short distances. They are too long to use to measure short distances. But if you don't have a shorter ruler, then you can use a meter stick.

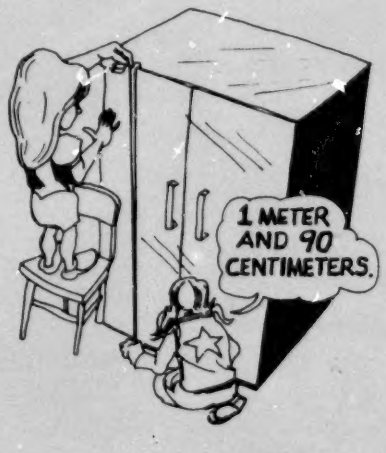
MEDIUM AND STRAIGHT

Perhaps you want to measure something a little larger than a plant. Maybe you want to measure the length and the width of a desk or a table. Perhaps you want to measure the heights of people in your class or your school.

You should use a measuring tool that is about the size of those things. You should use a meter stick or a two-meter stick. (A two-meter stick is just like a meter stick, only it is <u>two</u> meters long.) You could also use a short metal tape measure to find the length and the width of the desk or the table.

A ruler is too short to measure these things. You have to move it too many times. That makes your measurement less accurate. You could slip when moving the ruler. You could miscount the number or lengths, too. Using a meter stick or a metal tape measure prevents these errors and makes your measurement more accurate.

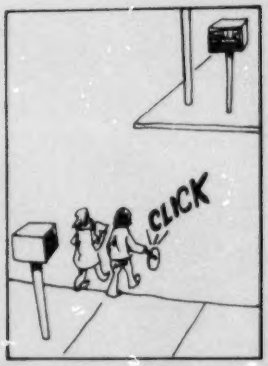
When you use the meter stick or the short metal tape measure, you can measure to the nearest millimeter. You can also measure to the nearest centimeter. You have to decide how accurate you need to be.



ACROSS THE STREET--A SPECIAL CASE

Usually when you measure a distance, you pick a tool that is about as long as the distance you want to measure. A street is about 10 meters wide. To measure the width of a street, you could use a metal tape measure. That would be the most accurate tool to use.

When you measure across a street, though, you have to think of other things. There may be a lot of traffic. Cars might run over your tape measure and bend it or break it. You will have to be in the street laying the tape measure out. Stretching it across the street could be dangerous.



A trundle wheel might be a better tool to use. It is not as accurate, but it is quick and easy to use. You can measure the width of the street in the time it takes you to cross it.

SEE "HOW TO" USE A TRUNDLE WHEEL

How accurate are the trundle wheel and the tape measure for measuring across a street?

With a tape measure you would probably round off to the nearest centimeter. Then your measurement would be off by at most 0.5 cm. If the street is 8 m wide, then your error is 0.5 cm in 8 m. That's a percentage error of

$$\frac{0.5\,\text{cm}}{8\,\text{m}} \times 100\% = \frac{0.5\,\text{cm}}{800\,\text{cm}} \times 100\% = 0.06\%$$

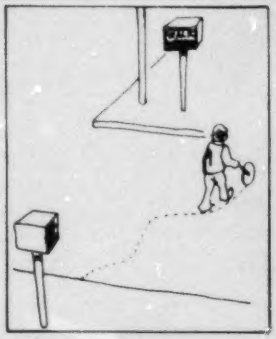
which is very small. You would probably make a larger error than that because of the unevenness of the curbs and by moving the tape measure slightly.

With a trundle wheel you can measure to the nearest 5 cm. Then your measurement could by off by 2.5 cm. If the street is 8 m wide, then your error is 2.5 cm in 8 m. That's a percentage error of

$$\frac{2.5\,\text{cm}}{8\,\text{m}} \times 100\% = \frac{2.5\,\text{cm}}{800\,\text{cm}} \times 100\% = 0.3\%$$

which is still very small. You would probably make a larger error than that while you were rolling the trundle wheel.

But these errors are just the errors in the measuring tool itself. They describe the accuracy of that particular tool. You also make human errors when you use each of the tools. You might move the tape measure slightly and that will make your measurement less accurate.



With the trundle wheel there are more chances to make a mistake than with a tape measure. You might miss counting one of the turns. You might roll it in a crooked line, or you might not roll it straight across the street. If might slip some as you roll it. All of these things would make your measurement less accurate. Your measurement might be off by 1 meter out of 8 meters. That's a percentage error of

$$\frac{1\,m}{8\,m} \times 100\% = 12.5\%$$

which is a large error.

If you are careful when you use a trundle wheel, most of these errors can be kept small, perhaps to 10 or 20 cm. That's a percentage error of

$$\frac{20\,cm}{8\,m} \times 100\% = \frac{20\,cm}{800\,cm} \times 100\% = 2.5\%.$$

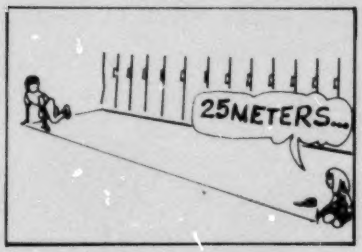
which is not too large.

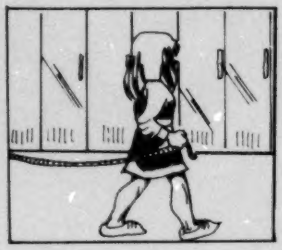
This means that you can use a trundle wheel to measure across a street if you use it carefully. You should use a tape measure if you want to be very accurate. But if you need to make the measurement quickly, then the trundle wheel is what you should use.

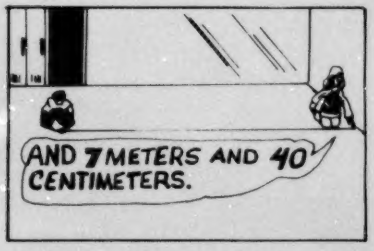
LONG AND STRAIGHT

Suppose you want to measure your classroom, the hallways in the school, the playground, the gymnasium, or the cafeteria. Perhaps you want to make a scale drawing of the cafeteria to try different arrangements of the tables and serving counter.

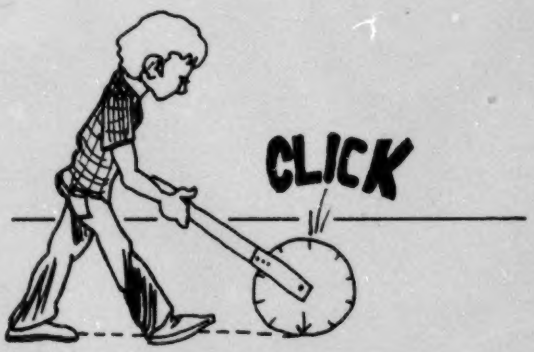
All these distances are much longer than two meters. You should use a measuring tool that is as close to the size of the length you want to measure as possible. You should use a long metal tape measure. You may still have to move it one or two times, but it is your best choice.







If you didn't have a tape measure, you could use a meter stick. But you would have to move it many times. There would be many chances of making a mistake. You could make an error each time you moved it. You could miscount the number of times you moved the meter stick. Your measurement would be less accurate than the one you would get by using a tape measure.



You could also use a trundle wheel to measure a hallway, the playground, the gymnasium, or the cafeteria. It would be less accurate than a tape measure, but it would be good enough for your purposes. There are more chances of making a mistake with a trundle wheel than with a tape measure. You might miscount the number of turns. You might not measure in a straight line or the trundle wheel might slip.

If you are measuring outside, the trundle wheel may not be as good as the tape measure, especially if the ground is bumpy. The trundle wheel measures the length of all the bumps and holes. If you are making a scale drawing, you will not want that extra length--it will make your drawing inaccurate. Then you should use a tape measure.

If the distance is long enough, the errors in using a trundle wheel might not matter, especially if you use it carefully. Because a trundle wheel is often easier to use, you might choose it instead of a tape measure.

If you use a trundle wheel carefully, you may be off by 0.5 meter to 1 meter. But if your measurement is 50 meters or more, your percentage error is no more than

$$\frac{1m}{50m} \times 100\% = 2\%$$

which is fairly small. If you use a tape measure, you may be off by 2 or 3 centimeters, and your percentage error is no more than

$$\frac{3cm}{50\,m} \times 100\% = \frac{3\,cm}{5000\,cm} \times 100\% = 0.06\%$$

which is very small.

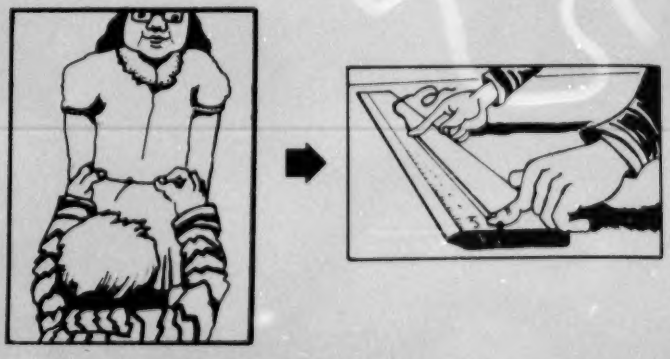
This means that for a long distance, along a straight path, you can use either a long tape measure or a trundle wheel. Which one you finally choose depends on how accurate you need to be and how fast you need to make the measurement. A tape measure is more accurate, but a trundle wheel is faster.

SHORT AND CURVED

Perhaps you need to measure around something or to measure along a curve. Perhaps you are going to make belts or wristbands or aprons and need to measure other kids' waists or their wrists or their chests. Perhpas you want to see how far a crayfish or a turtle crawls in a given length of time.

You can see that you need a measuring tool that will bend around a waist or wrist. A ruler or meter stick will not work. Neither will a metal tape measure nor a trundle wheel. You need a cloth tape measure like dressmakers use. It will go around someone's waist or wrist or chest.

If you do not have a cloth tape measure, you can use a piece of string and a meter stick. Make a small knot in one end. That will mark one end of your measuring tool. Then stretch the string around someone and hold it with your thumb and finger where the knot comes to. Still holding the place, lay the string along a meter stick. Read the length of the string from the meter stick. If you are careful, this will be about as accurate as using a cloth tape measure.



LONG AND CURVED

Sometimes you may want to measure a long distance that is along a curve. Maybe you have made a nature trail and you want to know how long it is. Maybe you are laying out a bicycle path and need to tell others how long it will be.

Then you should use a trundle wheel. It can go around curves while a metal tape measure cannot. If the distance is long (100 m or more), then the errors in using it will be small if you use it carefully. Be careful to count all the turns. Try not to let it wobble as you walk.

Even if your error is as much as one whole turn out of 100 turns, that is an error of only 1%. That is good enough for your purposes.

WHAT TO USE TO MEASURE YOUR DISTANCE

There are only a few things to remember when choosing a tool to measure distance.

- The measuring tool should be about the same length as what you are measuring. That way the tool either doesn't have to be moved or has to be moved only a few times. This helps make your errors smaller--human error in moving the tool, errors in miscounting the number of times the tool is moved, errors in not measuring along a straight line.
- The measuring tool should be as accurate as you need for your purpose.

Distance	Path	Measuring Device	Comment
Short	Straight	Ruler Meter stick	Ruler is better choice
Medium	Straight	Meter stick Short metal tape measure Trundle wheel	Meter stick or tape measure more accurate Trundle wheel easier and quicker
Long	Straight	Long metal tape measure Trundle wheel	Tape measure more accurate Trundle wheel easier and quicker
Short	Curved	Cloth tape measure String and meter stick	Cloth tape measure more accurate and easier to use
Long	Curved	Trundle wheel	

edc This material is based upon research supported by the National Science Foundation under Grant No. SED69-01071. Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the National Science Foundation.

ISBN: 0-89292-020-0

"HOW TO"

USE A TRUNDLE WHEEL

DO YOU NEED TO MEASURE A LARGE DISTANCE?

You may need to find the length of a bicycle path near your school. You could try using a tape measure. But the path might have a lot of curves. Or the tape measure might not be long enough. You would have to keep moving it after each measurement.

You can use a trundle wheel. It's good to use when you are measuring around curves. And you don't have to keep picking it up and moving it.

DO YOU NEED TO MEASURE A MEDIUM DISTANCE?

You may need to measure the width of a street. You can use a tape measure. But suppose a car comes while you are stretching it across?

Use a trundle wheel. It's faster. It won't get in the way as much.

You might need to measure your playground. Or your nature trail. Or the length of a block near your school.

You can use a trundle wheel for any of these things.

Inside, you can find out about trundle wheels: how to use them...how to measure around the wheel...how to measure different distances...how to get better measurements.

WHAT'S INSIDE PAGE

SKETCH OF A TRUNDLE WHEEL..... 2
STEP-BY-STEP--HOW TO USE A TRUNDLE WHEEL..... 3
HOW TO MEASURE AROUND YOUR TRUNDLE WHEEL..... 4
HOW TO USE A TRUNDLE WHEEL THAT ISN'T EXACTLY 1 METER..... 5
USING A TRUNDLE WHEEL TO MEASURE A LARGE DISTANCE..... 6
USING A TRUNDLE WHEEL TO MEASURE A MEDIUM DISTANCE..... 7
HOW CLOSE CAN YOU MEASURE?..... 12
DIAGRAM FOR CONSTRUCTING A TRUNDLE WHEEL..... 15

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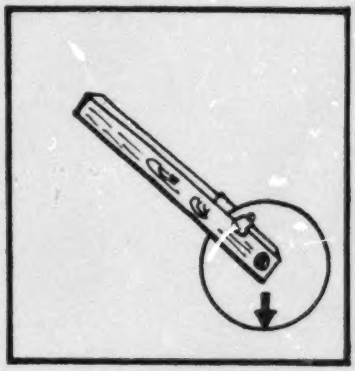
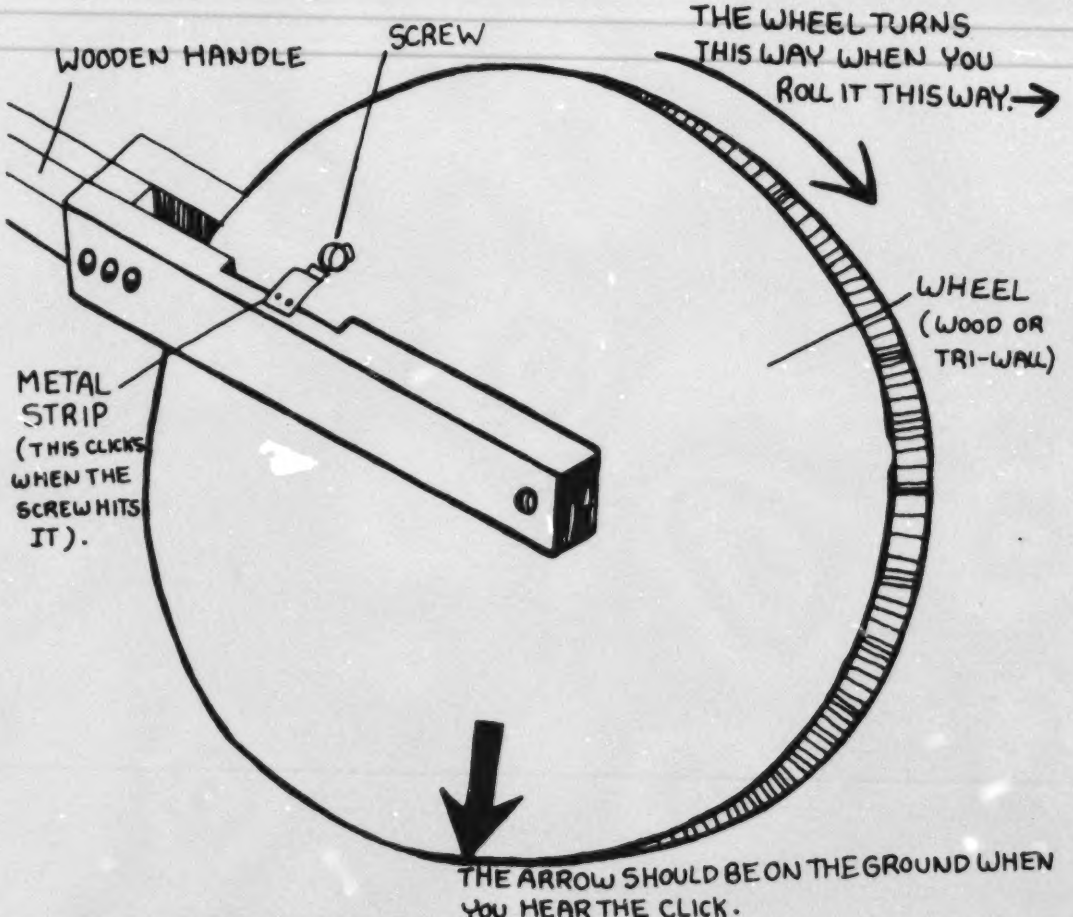
YOUR TRUNDLE WHEEL MAY LOOK LIKE THIS:



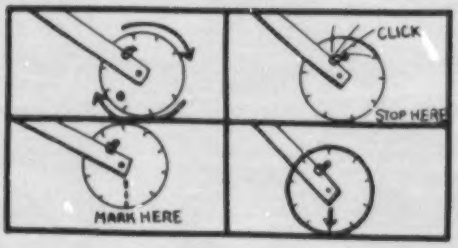

WOODEN HANDLE
SCREW
THE WHEEL TURNS THIS WAY WHEN YOU ROLL IT THIS WAY.
WHEEL (WOOD OR TRI-WALL)
METAL STRIP (THIS CLICKS WHEN THE SCREW HITS IT).
THE ARROW SHOULD BE ON THE GROUND WHEN YOU HEAR THE CLICK.

EACH TIME THE WHEEL TURNS ALL THE WAY AROUND, YOU WILL HEAR A CLICK. REMEMBER: **1 TURN = 1 CLICK**

A DIAGRAM ON THE LAST PAGE WILL HELP YOU MAKE YOUR OWN TRUNDLE WHEEL.

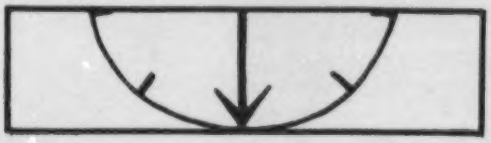
STEP-BY-STEP--HOW TO USE A TRUNDLE WHEEL

BEFORE you can use your trundle wheel, you need to MAKE A MARK FOR THE STARTING POINT. Here's how.



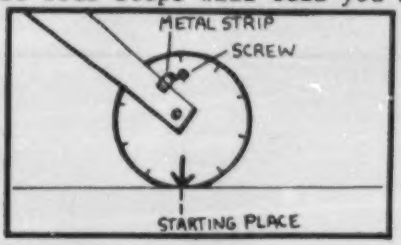
Turn the wheel slowly. Stop turning when the screw touches the metal strip. (You will hear it click.)

Mark the bottom of the trundle wheel where it touches the ground. You can make an arrow like this.



Now you are ready to use the trundle wheel. These four steps will tell you how.

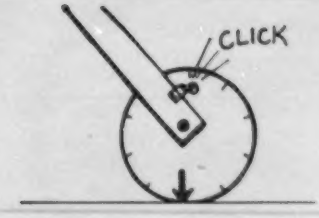
1. START ON THE MARK.



Find the arrow on your trundle wheel. Put the arrow over the place where you want to start measuring. Hold the handle so that the screw is touching the metal strip.

2. PUSH YOUR TRUNDLE WHEEL.

The wheel will turn like this. Move your trundle wheel forward. Keep the handle at the same height. Go slowly.



You will hear a click. This happens when the screw hits the metal strip. It means the wheel has gone around once. (Remember: 1 turn equals 1 click.

3. COUNT THE CLICKS.

The clicks will tell you how many times your trundle wheel has gone all the way around.

Remember: Try to walk in a straight line. And don't go too fast. Then your measurements will be better.

4. FIGURE HOW FAR YOU MEASURED.

Multiply the number of turns by the distance around your trundle wheel. This will tell you how far you measured.

NUMBER OF TURNS x DISTANCE AROUND = DISTANCE YOU MEASURED

Suppose you counted 9 clicks. This means 9 turns.

Now suppose your trundle wheel is 1 meter around. This means that there is 1 meter for each turn. You would find out how far you measured like this:

9 clicks 9 turns x 1 meter for each turn = 9 meters

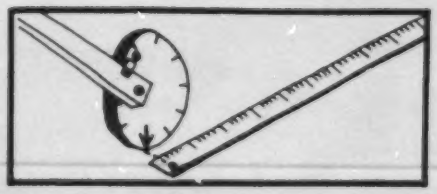
The distance you measured is 9 meters.

If you just made a trundle wheel, you might not know the distance around it. Read the next section to find out how to measure the distance around it.

HOW TO MEASURE AROUND YOUR TRUNDLE WHEEL

To use your trundle wheel, you need to know the distance around the wheel. Here is a good way to measure it.

Stretch out a tape measure on a smooth floor. Try to get it very straight. Now place the arrow on the trundle wheel at the beginning of the tape measure. But keep the trundle wheel a little distance to one side.



Roll the trundle wheel forward in a straight line. (Keep it close to the tape measure.) Count ten clicks. Now read the tape measure to see how far you went.

This trundle wheel went 9 meters and 50 centimeters in 10 turns. That's 950 centimeters for 10 turns.

To find out how far the wheel went in 1 turn, divide 950 centimeters by 10 turns. Like this:

$$\frac{950 \text{ centimeters}}{10 \text{ turns}} = 95 \text{ centimeters for one turn.}$$

Remember, in one turn a trundle wheel goes all the way around. So this trundle wheel is 95 centimeters around.

▲▲▲

Suppose your trundle wheel is more than 1 meter around. Suppose it's 1 meter and 10 centimeters around.

If you counted 5 clicks...

5 clicks ⇨ 5 turns x (1 meter and 10 centimeters) = 5.50 meters

Here's another example. If you counted 11 clicks...

11 clicks ⇨ 11 turns x (1 meter and 10 centimeters) = 11 meters and 110 centimeters

Change this to 12.10 meters.

You might also change the distance around the trundle wheel to all meters before you multiply (1.1 meters), or to all centimeters (110 centimeters).

Now you are ready to measure a distance with your trundle wheel.

USING A TRUNDLE WHEEL TO MEASURE A LARGE DISTANCE

You can use a trundle wheel to measure a large distance--like a nature trail or a bicycle path. Here's how.

Suppose your class has just made a nature trail. Suppose you want to find out how long it is. A trundle wheel is easy to use for this.

Draw a line in the dirt at the beginning of the trail. This is where you start. Push the trundle wheel forward. Count the clicks. Stop when you get to the end of the trail. Make a line in the dirt where you stopped.

Now figure how far you measured. Suppose your trundle wheel is 1 meter around. And suppose you counted 272 clicks. Then

272 clicks ⇨ 272 turns x 1 meter for each turn = 272 meters.

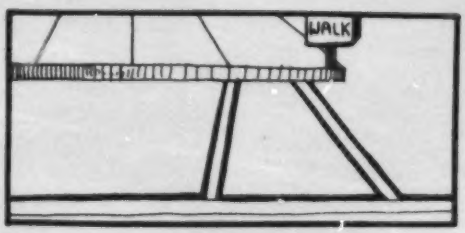
Suppose the nature trail is not exactly 272 turns. You counted 272 turns, and then you went a little farther. This distance is less than a full turn.

Don't worry about this little distance. It is less than 1 meter. Even an error of 1 meter out of 272 meters is small. Just count the number of full turns. Your measurement will be accurate enough.

REMEMBER: FOR A LARGE DISTANCE, LIKE A NATURE TRAIL OR A BICYCLE PATH, YOU NEED TO COUNT ONLY FULL TURNS.

USING A TRUNDLE WHEEL TO MEASURE A MEDIUM DISTANCE

Most of the time you will use a trundle wheel to measure large distances. But sometimes you may need to use a trundle wheel to measure a medium distance, such as the distance across a street.



If the street is busy, it will be better to use a trundle wheel than a tape measure. A trundle wheel is quicker. It won't get in the way as much.

The distance across a street isn't far. It may be about 7 turns of your trundle wheel. But suppose there is a certain distance left after the seventh turn. Suppose this distance is not a full turn.

If your trundle wheel is 1 meter around, this extra distance might be almost as much as 1 meter. One meter is a big error for a measurement of 7 meters.

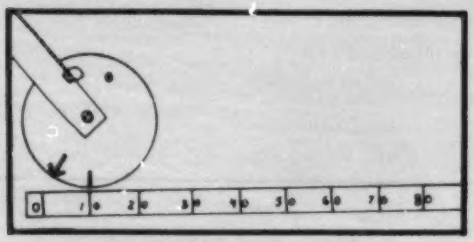
When you are measuring across a street, you still need to measure this extra distance. It will make your measurement more accurate. The next sections will help you measure this extra distance.

REMEMBER: FOR A MEDIUM DISTANCE, LIKE ACROSS A STREET, YOU NEED TO MEASURE CLOSER THAN ONE TURN.

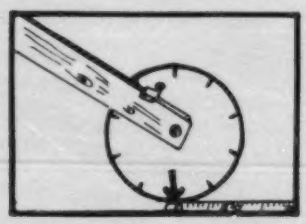
CALIBRATING YOUR TRUNDLE WHEEL

Before you can measure closer than one turn, you will need to put marks on your trundle wheel. This is called CALIBRATING YOUR TRUNDLE WHEEL. Here's how to do it.

Stretch out a tape measure on a smooth floor. Keep the tape measure very straight. Place the trundle wheel at the beginning of the tape measure. Make sure the arrow on the trundle wheel is next to the 0-centimeter mark on the tape measure.

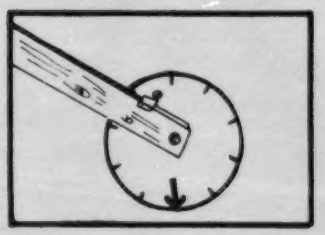


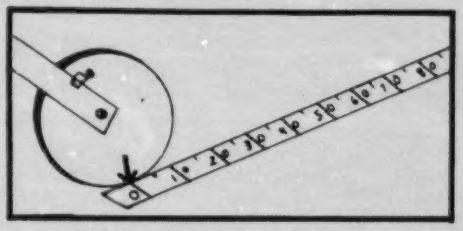
Roll the trundle wheel forward again. Stop next to the 20-centimeter mark on the tape measure. Make another mark on the trundle wheel.



NOW DO IT ALL OVER AGAIN. Start the arrow on the trundle wheel at the 0-centimeter mark on the tape measure. Make the marks the same way you did the first time. But leave the first marks on.

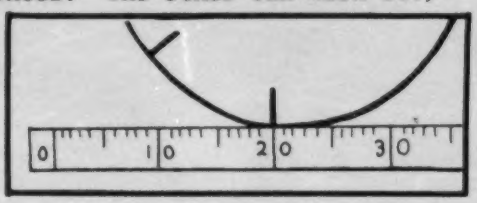
It is good to make marks around the trundle wheel more than once. Then you can be sure you did not make a mistake the first time.



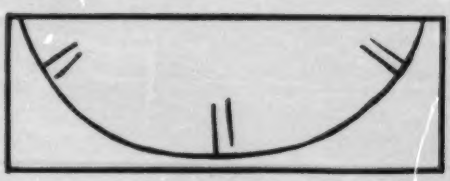


ROLL THE TRUNDLE WHEEL FORWARD. Go very slowly. Stop next to the 10-centimeter mark on the tape measure. Make a mark like the one in the picture where the trundle wheel touches the floor. Draw the mark with a pencil or a piece of chalk.

(You will need two people to do this. One person can push the trundle wheel. The other can mark it.)



Do the same next to the 30-centimeter mark. And the 40-centimeter mark. Make a mark every 10 centimeters. Do this all the way around the trundle wheel. Stop when the arrow is touching the floor again.

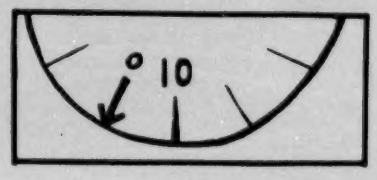


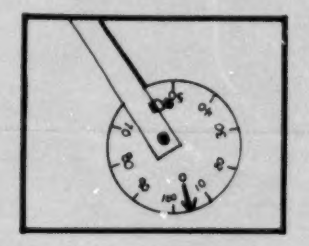
Make marks around the trundle wheel about five times.

Now you will have a lot of marks. They should be in clumps. Here, there are five marks in a clump.

You can't tell which mark in each clump is the best. SO USE THE MIDDLE MARK IN EACH CLUMP. Make it darker. Then erase the others. Do this for each clump.

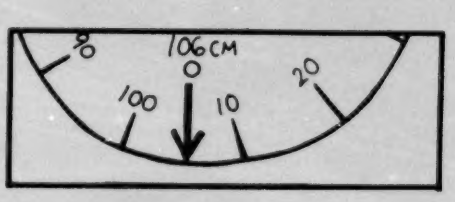
NOW YOU ARE READY TO MAKE NUMBERS ON THE WHEEL. Start at the arrow. Mark this 0. Turn the wheel. Make sure you turn it the same way it goes when you are measuring something. Write 10 above the first mark.





Write 20 above the second mark. And 30 above the third mark. And so on. Count by 10s until you get to the arrow.

Is your trundle wheel 90 centimeters around? Or 1 meter around? Or 110 centimeters around? WRITE THE DISTANCE AROUND ABOVE THE 0-CM MARK. This trundle wheel is 106 centimeters around.



CALIBRATE ONLY ONE SIDE OF YOUR TRUNDLE WHEEL

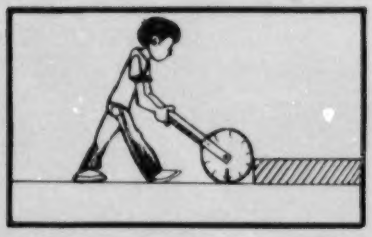
Make sure the calibrated side is facing the same way each time.

Now you have calibrated your trundle wheel. You are ready to measure a distance closer than one turn.

You are ready to measure a medium distance. Like across a street. Next you will find out how to measure across a street.

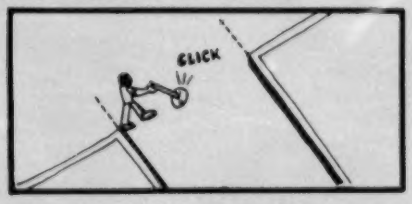
MEASURING A STREET AT AN INTERSECTION

Imagine you are measuring across River Street where it crosses Bridge Street. You don't want the curb to get in the way.

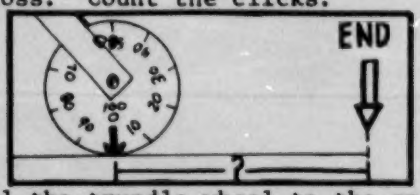


Make a mark for starting your measurement. Draw a straight line from the edge of the curb on River Street. Draw it a short distance into Bridge Street. Make a mark for stopping in the same way. (You can use a piece of chalk for this.)

Now measure across the street. You will need to watch cars on both streets. Be very careful. Push the trundle wheel across. Count the clicks.

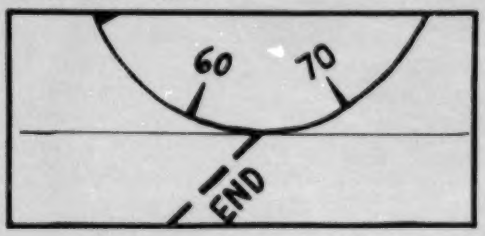


Suppose you count 7 clicks. But there is still a little distance left to the end.



Roll the trundle wheel to the end. Now read the distance the trundle wheel went. This trundle wheel went more than 60 centimeters. It is about half-way between 60 and 70 centimeters. Round this off to 65 centimeters.

SEE "HOW TO" ROUND OF DATA AS YOU MEASURE.



Now you can figure your total measurement. Suppose the trundle wheel is 106 centimeters around. You went 7 clicks. Figure how far that is.

7 clicks ➡ 7 turns x 106 cm for each turn = 742 cm

Round this off to 740 cm.

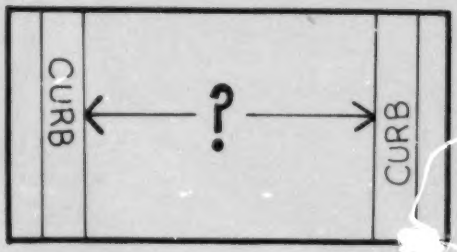
Now add the extra distance.

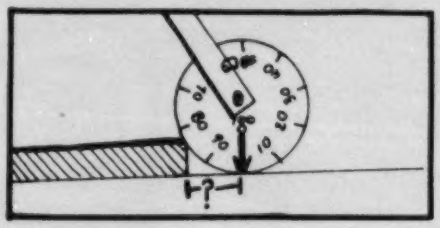
740 cm + 65 cm = 805 cm.

The street is about 805 centimeters across. That's 8.05 meters across.

MEASURING A STREET IN THE MIDDLE OF A BLOCK

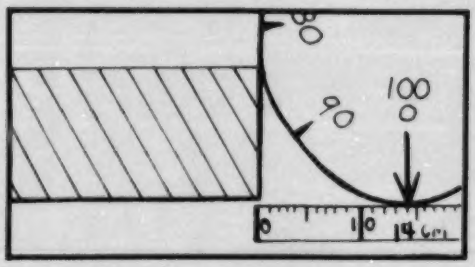
Maybe you want to measure across a street. The street has a curb on each side. You want to measure in the middle of the block. But there is no break in the curb where you want to measure. Here's what you do.





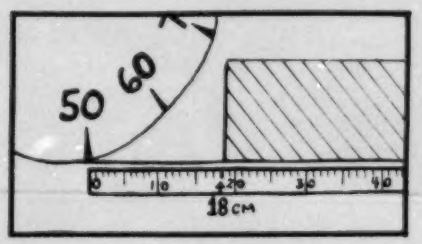
Start your trundle wheel at the curb. The bottom of the trundle wheel won't reach the curb. So the trundle wheel can't measure this little distance.

Use a ruler to measure the little distance. Put the trundle wheel as close to the curb as you can. Then measure between the bottom of the curb and the 0 mark on the trundle wheel. The distance in the picture is 14 centimeters. Round this off to 15 centimeters.



Now push the trundle wheel across the street. Measure this distance with the trundle wheel. In the picture, it is 6 meters and 50 centimeters.

The bottom of the trundle wheel won't reach the curb on the other side. Measure this little distance. In the picture, it is 18 centimeters. Round this off to 20 centimeters.



Now add all these rounded measurements.

6 m	50 cm	
	15 cm	
+	20 cm	
6 m	85 cm	

The street is about 6.85 meters wide.

HOW CLOSE CAN YOU MEASURE?

When you measure with a trundle wheel, you try to be accurate. But you can't be exact. Lots of things happen that make your measurements not exact. These things are called *errors*. You can't always avoid errors. But you can get better measurements if you know about errors.

One Kind of Error--YOUR TRUNDLE WHEEL IS NOT EXACT

Are you measuring a large distance, like a bicycle path or a nature trail? Remember when you measured around your trundle wheel. You tried to be accurate. But you couldn't tell *exactly* how far around your trundle wheel is. The distance could be a little more. Or it could be a little less. The error isn't much. But it makes your measurement not exact. Especially if your measurement has a lot of turns.

Are you measuring a medium distance, like across a street?

Remember when you calibrated your trundle wheel? You tried to be accurate when you made the marks all the way around. But you couldn't be exact. Maybe the 10-cm mark should really be a little more to the right. Or the left. And the same for the other marks. The errors aren't much. But they make your measurements not exact when you are measuring closer than one turn.

Another Kind of Error--THE WAY YOU MEASURE IS NOT EXACT

Suppose you are measuring a bicycle path. Even if you are very careful, you might make a mistake. You can make little mistakes without even noticing. But these mistakes make your measurement not exact.

Here are some mistakes that are easy to make.

☆ *You might not push the trundle wheel in a straight line. It might wiggle and slip when it moves.*

☆ *You might roll the trundle wheel backwards.*

☆ *You might miss a click. Or count the wrong number of clicks.*

Suppose you are measuring across a street. You can have the same errors as someone measuring a bicycle path. But you can also have this error:

☆ *You might not start exactly at the 0 mark on the trundle wheel.*

This error doesn't matter much if you are measuring a large distance. But it does matter if you are measuring a medium distance.

You don't have to worry about all of these errors each time you measure.

This chart will help you figure out when each error is important.

	Watch for this when you measure...	
	Large distance	Medium distances
The distance around your trundle wheel is not exact.	★	
The marks you made when you calibrated are not exact.		★
The trundle wheel might wiggle and slip.	★	★
You might roll it backwards.	★	★
You might miss a click or count the wrong number.	★	★
You might not start exactly on the 0-cm mark.		★

WHAT YOU CAN DO TO MAKE YOUR MEASUREMENTS MORE EXACT

☆ *1. MEASURE SLOWLY AND CAREFULLY.*

Don't run. Push the trundle wheel slowly. Hold it firmly and try to move it in a straight line. It will slip a little even if you do this. But if you measure carefully, your measurement will be more accurate.

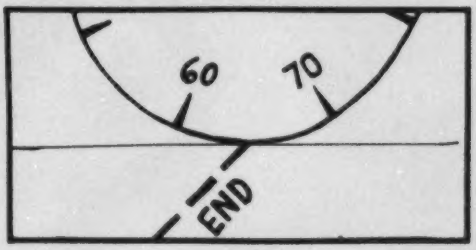
☆ *2. MAKE SEVERAL MEASUREMENTS TO TAKE THE MEDIAN MEASUREMENT.*

Don't measure something just once. Measure it three times. Or five times. Or more. Suppose you have five measurements of your bicycle path. You can't tell which one is the best. So take the middle number (called the median) of the five measurements. "How To" Find the Median will tell you more about this.

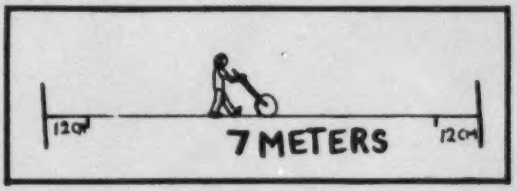
BICYCLE PATH FROM School to Mill Street

296 M
299 M
301 M
301 M
303 M

☆3. *ROUND OFF YOUR MEASUREMENTS TO THE NEAREST 5 CENTIMETERS WHEN YOU ARE MEASURING CLOSER THAN ONE TURN.*



Maybe you are measuring across a street. Suppose at the end of your measurement your trundle wheel looks like the one in the picture. The extra distance looks like about 63 or 64 centimeters. Round it off to 65 centimeters. Read "How To" Round Off Data.



Suppose you measure your street in the middle of a block. The distance the trundle wheel measures is 7 meters. And the distance from the bottom of the trundle wheel to the curb is 12 centimeters on each side. Round each measurement off to 10 centimeters.

Now add your measurements.

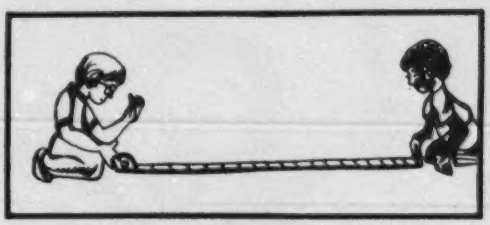
7 m + 10 cm + 10 cm = 7 m and 20 cm or 7.20 m.

That's as accurate as you can get.

When you are using a trundle wheel to measure a medium distance, don't try to measure closer than 5 centimeters. That's about as accurate as the trundle wheel can be.

☆4. *TRY A DIFFERENT MEASURING INSTRUMENT.*

A trundle wheel might not be the best tool for what you are doing.

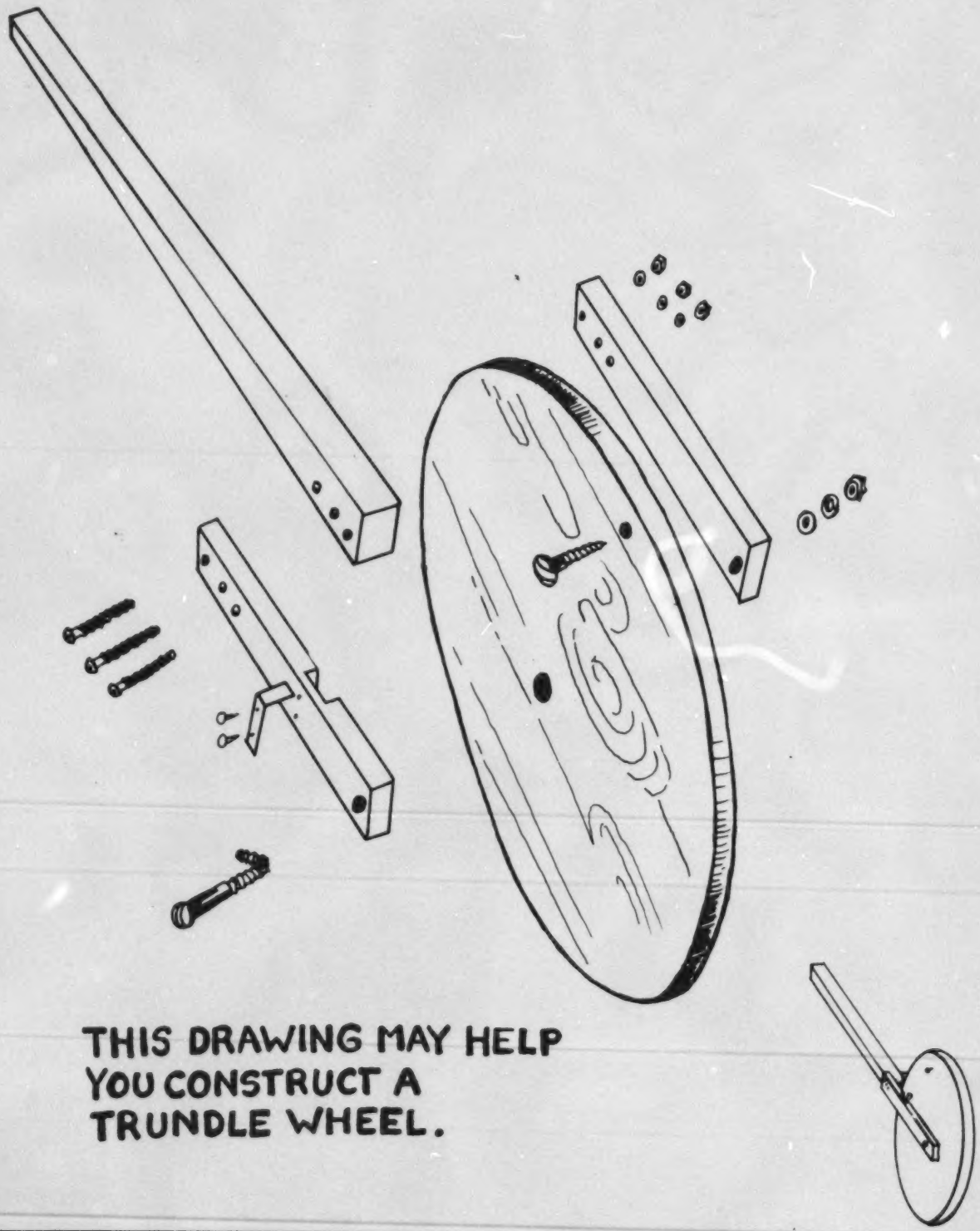


Do you need to be more accurate when you measure? Maybe you are measuring 50 meters for a race. Then use a tape measure.

Do you want to avoid measuring bumps and holes in the ground? Then use a tape measure.

If you want to find out more about other tools, read "How To" Choose the Right Tool to Measure Distance.

DIAGRAM FOR CONSTRUCTING A TRUNDLE WHEEL



THIS DRAWING MAY HELP YOU CONSTRUCT A TRUNDLE WHEEL.

"HOW TO"

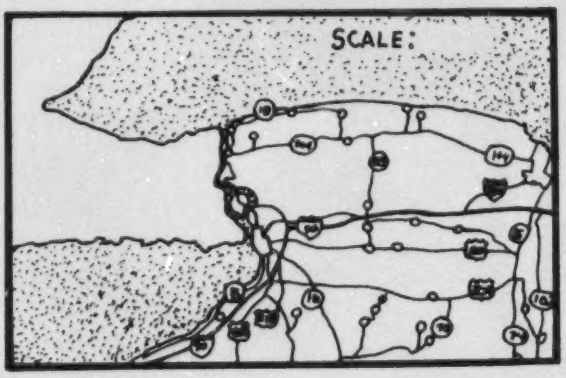
MAKE A SCALE DRAWING

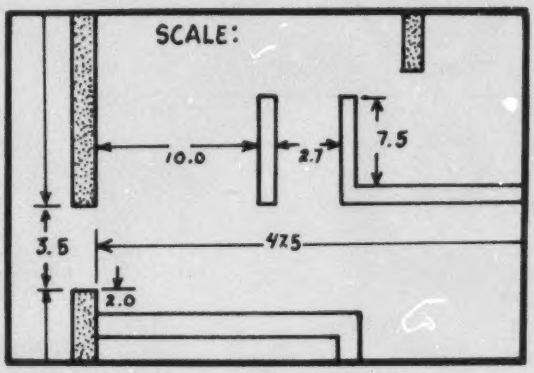
WHY MAKE A SCALE DRAWING?

Suppose you want to move the furniture in your classroom or to change the way the tables in the lunchroom are arranged. You need a plan before you start moving things. You need a drawing that shows where the tables or furniture should go. The drawing has to be smaller than the room itself. To make sure that the drawing is a good one, you should make a scale drawing.

WHAT IS A SCALE DRAWING?

A scale drawing is a picture of something as you would see it if you were looking down on it. Scale drawings make the things smaller or bigger. A road map is a scale drawing. A blueprint is a scale drawing. The distances on those scale drawings are smaller than the real distances by a certain proportion. The amount the distances are smaller than the real distances is given by the scale. The scale is written on every scale drawing.





This booklet tells how students make scale drawings. It also tells you how to make scale drawings bigger or smaller. Read the examples and decide what you should do for the scale drawing you want to make.

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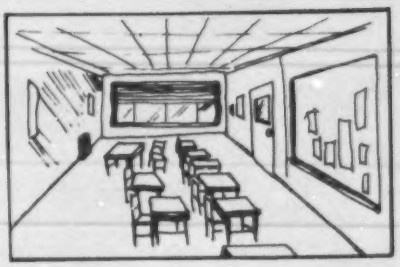
STEPS IN MAKING A SCALE DRAWING

☆1. DECIDE HOW TO MAKE THE DRAWING
☆2. DECIDE ON A SCALE
☆3. DECIDE HOW ACCURATE THE MEASUREMENTS NEED TO BE
☆4. MAKE THE MEASUREMENTS
☆5. DRAW THE SCALE DRAWING.

MAKING A SCALE DRAWING OF A CLASSROOM: MOVE IT HERE

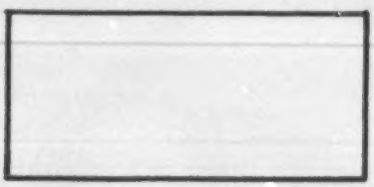


This story about Joe, Bernice, Janet, and Michael shows how they made a scale drawing of their classroom. They used the drawing to show different furniture arrangements. They followed the five steps and used graph paper for their drawing.

☆ *1. They Decide How to Make the Scale Drawing.*

Joe, Bernice, Janet, and Michael look at their room. They see that the sides are straight. They see that the corners are square.

"If we could look at the room from the roof, the sides would look like this," says Joe. He draws on a sheet of paper.



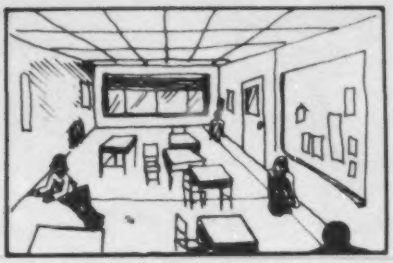
"It looks just like a sheet of paper," says Bernice. "We can use graph paper. It's all marked off in squares. It will make it easy to draw desks and square things in the room."

☆ *2. They Decide on a Scale.*

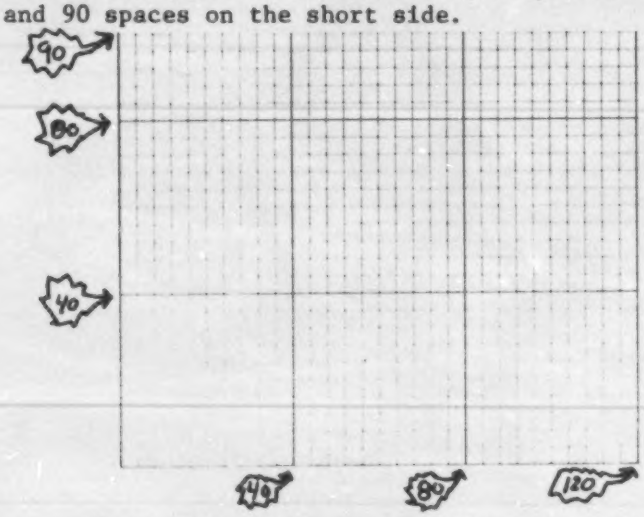
"We're going to have to decide how much smaller to make the room for our drawing," says Janet. "But we want the drawing to fill up most of the graph paper. Let's ask the teacher how to do it."

The teacher tells the group that they are going to have to decide on a scale. The scale will tell them how much smaller everything has to be for their scale drawing. "To decide on a scale, you first measure the length and width of the classroom. The length will have to fit on the long side of the graph paper, and the width will have to fit on the short side," the teacher explains.

Joe and Bernice measure the length of the classroom. Janet and Michael measure the width. They use a ten-meter tape measure and measure each distance several times. They decide to use the median measurement. The median length is 9 meters and 68 centimeters, or 968 centimeters. The median width is 8 meters and 60 centimeters, or 860 centimeters.



"Let's count the number of spaces on the graph paper," suggests Janet. "That will help us decide on a scale." Because they are using graph paper that is marked off 5 lines to a centimeter, they count 120 spaces on the long side and 90 spaces on the short side.



"We'll have to fit the 968 centimeters into the 120 spaces on the long side of the graph paper," says Michael.

"Then our scale can be how much of the length of the room can be shown by one space," adds Joe. "Let's figure it out. We have to divide the length of the room (968 centimeters) by the number of spaces (120)." He writes:

$$\frac{968 \text{ cm}}{120 \text{ spaces}} = 120\overline{)968} = 8.0 \text{ cm per space}$$

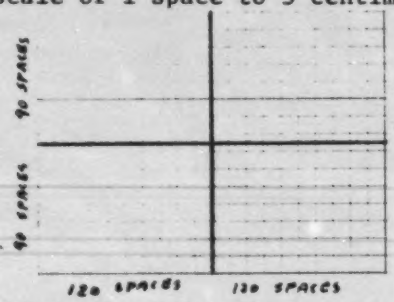
$$\begin{array}{r} 8.0 \\ 120\overline{)968} \\ \underline{960} \\ 80 \end{array}$$

"One space will show about 8 centimeters in the room" reports Joe. "Let's make our scale 1 space to 10 centimeters. Ten is an easier number to work with."

"That scale is too small," says Bernice. "Our bookcase is 120 centimeters long but it's only 30 centimeters wide. That will be only 3 tiny spaces on the scale drawing."

"We can use a scale of 1 space to 5 centimeters," says Joe. "Then the bookcase will cover 6 spaces. But our paper will have to be twice as large for the room to fit on it."

The group decides to tape four sheets of graph paper together for their scale drawing, and use a scale of 1 space to 5 centimeters.



"We'd better make sure that the width of the room fits on the paper with this scale," says Janet. "We can multiply 5 centimeters times 180 spaces to find out how much distance can be shown on the width of the paper." She writes:

5 cm per space x 180 spaces = 900 cm

"The width of the room is 860 centimeters, says Michael. "It just fits."

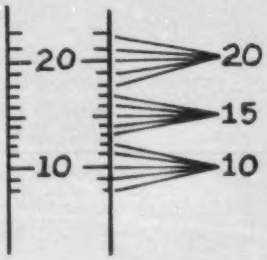
☆ *3. They Decide How Accurate Their Measurements Have To Be.*

"It took us a long time to measure the length and width of the room," says Janet. "We measured to the nearest centimeter. Do we have to be that accurate with all our measurements? Maybe we can round off more."

The group reads "How To" Round Off Data as You Measure. "We counted the number of small spaces on our graph paper," says Michael. "We can't see anything any closer than one space. So we can round off to the distance shown by one space."

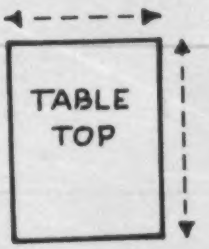
"Our scale is 1 space to 5 centimeters," replies Bernice. We can round off our measurements to the nearest 5 centimeters. It will make it a lot faster to measure."

"Then we'd make the length 970 centimeters, rather than 968 and the width will stay 860 centimeters," says Michael.



☆ *4. They Make the Measurements.*

Joe, Bernice, Janet, and Michael measure all of the furniture in the room. They measure the length and width of furniture that takes up a rectangular space, like desks and bookcases. They measure the diameter of round objects like wastebaskets and round tables. They round off to the nearest 5 centimeters, and put their data on a chart like this.

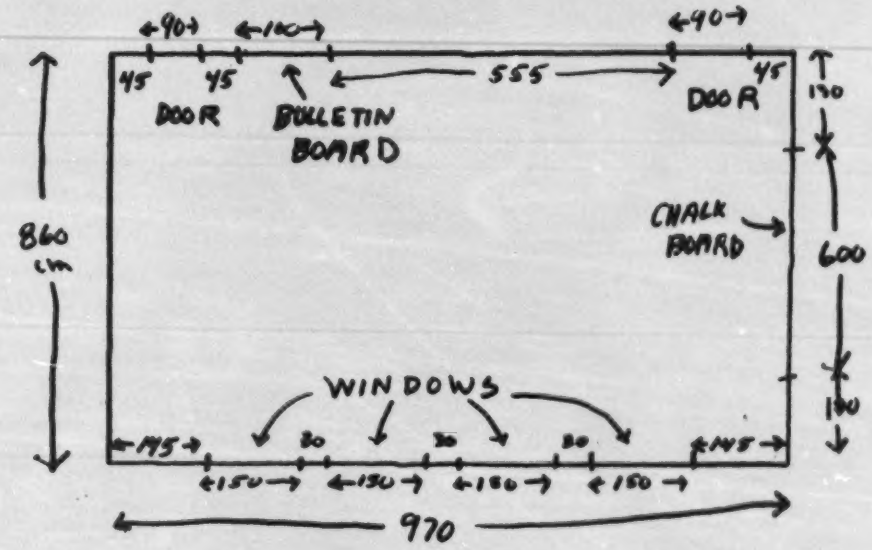


ITEM	LENGTH (cm)	WIDTH (cm)	DIAMETER (cm)
Room	970	860	—
Desks	80	60	—
Big Tables	180	85	—
Small Tables	—	—	100
Book cases	120	30	—
Fish Tank	55	25	—
Waste basket	—	—	35
Teacher's Desk	120	70	—

"We'll want to put the doors and windows on the scale drawing," says Janet.

"How about the chalkboard and bulletin board?" asks Bernice. "We don't want to put things in front of them"

The group measures distances along the sides of the room so that they can put the doors, windows, chalkboard, and bulletin board at the right places on the drawing. They make a rough sketch of the room and write their measurements on the sketch. "That way," says Joe, "we'll know exactly what distance we measured.



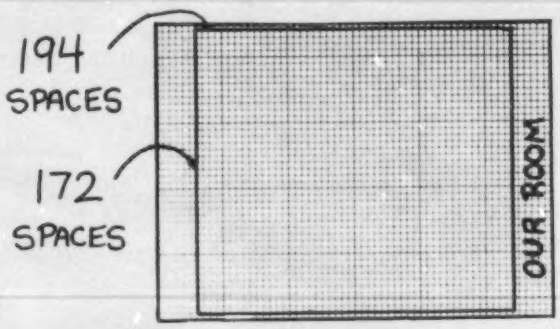
☆ 5. *They Make the Scale Drawing.*

Before they start to draw on the graph paper, the group remembers that they have to divide their measurements by the amount of their scale.

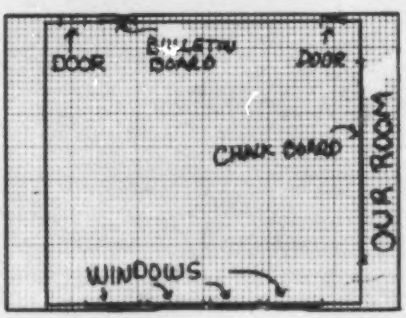
"Our scale is 1 space to 5 centimeters," says Janet. "So we have to divide each measurement by 5." They put the scaled measurements on their data chart.

ITEM	LENGTH (cm)	WIDTH (cm)	DIAMETER (cm)
Room	970 → 194 sp.	860 → 172 sp.	—
Desks	80 → 16 sp.	60 → 12 sp.	—
Big Tables	180 → 36 sp.	85 → 17 sp.	—
Small Tables	—	—	100 → 20 sp.
Bookcases	120 → 24 sp.	30 → 6 sp.	—
Fish Tank	55 → 11 sp.	25 → 5 sp.	—
Waste basket	—	—	35 → 7 sp.
Teacher's Desk	120 → 24 sp.	70 → 14 sp.	—

To make the drawing, they first draw lines for the length and width of the room along the sides of the graph paper.

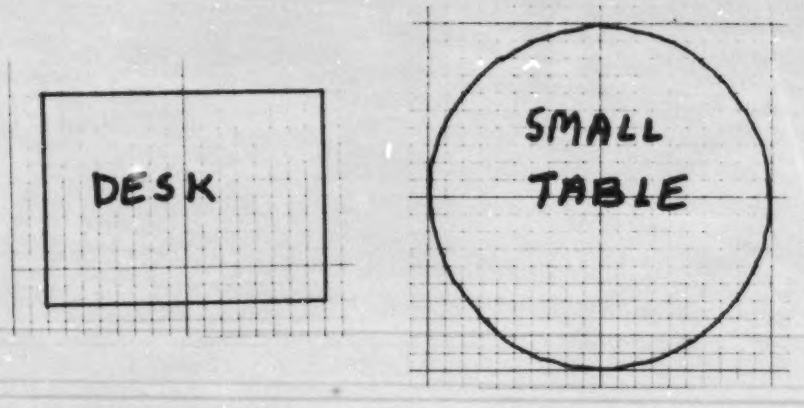


They next show where the windows, doors, chalkboard, and bulletin board are on those lines.

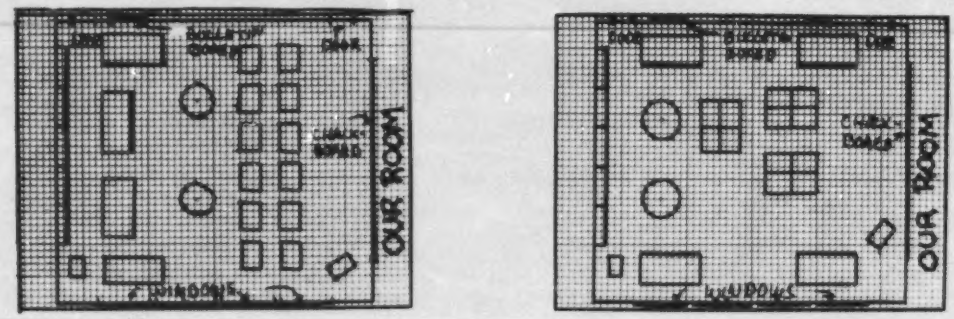


"We can't draw the furniture on the graph paper," sayd Joe. "We won't be able to try out different arrangements."

"Let's cut out separate pieces from another sheet of graph paper," suggests Bernice. "Then we can move them around." The group agrees to this idea. They draw the furniture to scale on another piece of graph paper, and then cut the pieces out.



Because the group wants to show two different arrangements of their room, they make two sets of cutouts of the furniture and two room outlines. Their two arrangements look like this.

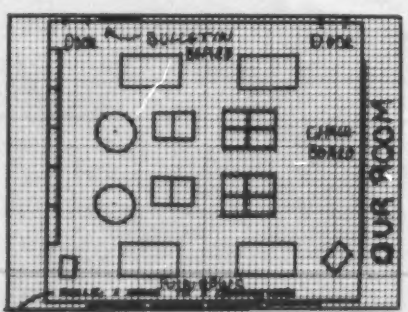


"Is there enough space between the tables and in front of the door?" asks the teacher. "There are fire regulations that tell how much space must be left in certain parts of a room."

To find out, the group counts the number of spaces on the scale drawing. Then they multiply the number of spaces by 5 centimeters. They do this because the scale is 1 space to 5 centimeters. They check with the fire department and find out that they have left enough space in one arrangement but not in the other.

Before they decide on a final arrangement of the furniture, they also check the space in front of the chalkboard and windows. The fish tank is moved so that is is close to an electrical outlet because the pump has to be plugged into an outlet.

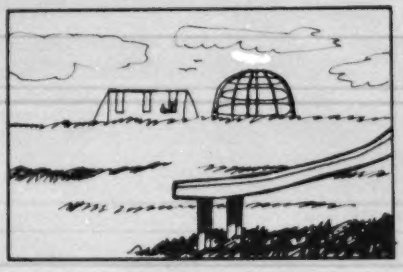
Finally, the class approves their plan. As they move the furniture around, they look at the scale drawing. To make sure that everyone understands the drawing, they write the scale on it.



MAKING A SCALE DRAWING OF A PLAYGROUND: A PLACE FOR A TUNNEL

In the last story the students made a scale drawing of a classroom. They used graph paper because the room was rectangular and a large enough drawing could be put on four sheets of graph paper. This story tells how students made a scale drawing of a playground on plain paper.

The boys and girls in Charlie's class want to get some new things for their playground. They want to put a tire climb and a tunnel on the playground. They think that they may have to move some of the slides or swings to find space for the tire climb and tunnel.



"We can make a scale drawing of the playground," suggests Charlie. "We can put all the playground equipment on it and see where we can put the new things." The others agree to help Charlie make a scale drawing of the playground.

☆ *1. They Decide How to Make the Scale Drawing.*

Charlie, Bob, Joyce, and Susan look closely at the playground during lunch that day. They see that it has straight sides and square corners, and is quite large.

"It will take a lot of graph paper to make a scale drawing that's big enough," says Bob. "Let's use the sheet of cardboard that's in the corner of the room."

☆ *2. They Decide on a Scale.*

Joyce and Susan measure the cardboard they are going to use for the scale drawing and find that it is 90 centimeters long and 70 centimeters wide.

"Now that we know the size of the cardboard, we have to measure the length and width of the playground" says Joyce. "Then we can figure out what scale to use for our drawing."

Charlie and Bob measure the length of the playground several times with a trundle wheel. They use the marks on the trundle wheel to measure the part that is less than one turn. They find that the median measurement is 85.30 meters. Joyce and Susan measure the width of the playground. The median of their measurements is 46.95 meters.

"The length of the playground has to fit on the long side of the cardboard." says Susan. "We'll have to divide the length of the playground (85.30 meters) by the length of paper (90 centimeters). That will tell us what distance can be shown on 1 centimeter of paper." She writes:

$$\frac{85.30\ m}{90\ cm} = 90\overline{)85.30} = .94\ \frac{m}{cm}$$

$$\begin{array}{r} .94 \\ 90\overline{)85.30} \\ \underline{810} \\ 490 \\ 360 \end{array}$$

"We can show 0.94 meters on 1 centimeter of paper," says Bob. "That's almost 1 meter. Our scale can be 1 centimeter to 1 meter."

"Wait a minute," says Charlie. "We'd better check to see whether the width of the playground will fit on the width of the cardboard."

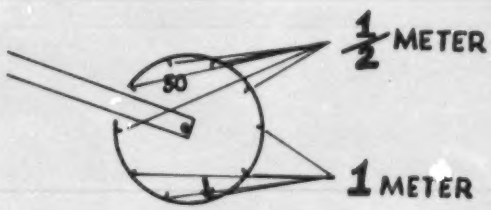
"The width of the cardboard is 70 centimeters," answers Susan. "With a scale of 1 centimeter to 1 meter we can show 70 meters on the width of the paper."

"The playground is 46.95 meters wide," reports Joyce. "It'll fit on the paper and there will be some space left over. We can put the scale and the title in the extra sapce."

☆ *3. They Decide How Accurate Their Measurements Need to Be.*

"We still have to measure the space taken up by the swings, slides, monkey climb, and baseball diamong," says Bob. "How accurate do our measurements need to be?"

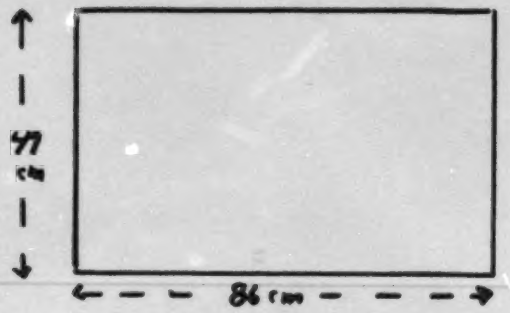
"We can put things closer than 1 centimeter on the paper," says Susan. "So we should measure closer than 1 meter. Let's measure to the nearest half meter. I don't think that a half meter difference in the placement of playground equipment will change anything."



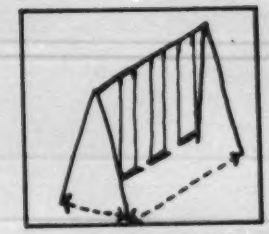
The group agrees to measure the space taken up by the playground equipment to the nearest half meter.

☆ *4. They Make the Measurements.*

Charlie, Bob, Joyce, and Susan have already measured the length and width of the playground. Before they make any more measurements, they make a rough sketch of the playground. They figure that they can put their measurements right on the sketch. It will help them remember exactly what distances they have measured. They round off the length and width measurements to the nearest half meter. They round off the length measurement from 85.30 meters to 85 meters, and the width measurement from 46.95 meters to 47 meters. They put these measurements on the sketch.

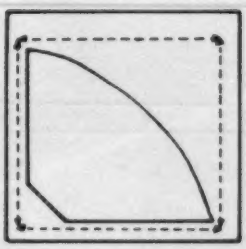


Next they measure the space the swings, the slides, and the monkey climb take up. Charlie and Bob measure the swing area. They agree that it is a rectangular-shaped area, and so they measure the length and width of the space the slides take up.

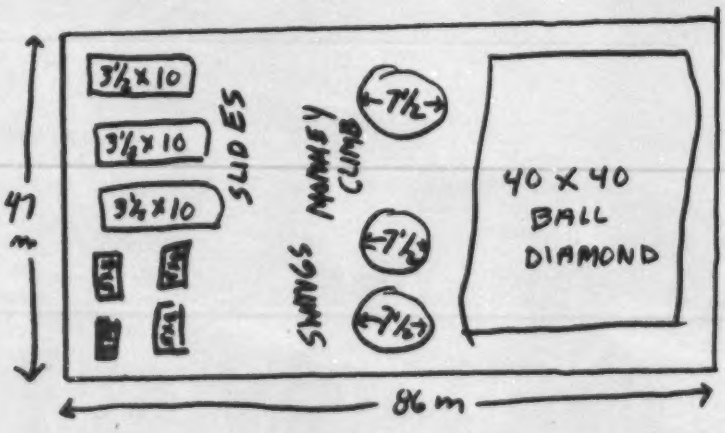


Joyce and Susan measure the space taken up by the monkey climb. It is a round monkey climb, and so they measure the diameter of the round space the monkey climb takes up.

Susan and Joyce also measure the space the baseball diamond takes up. It's an odd shape but almost fills up a square area, so they measure the length and width of that area.

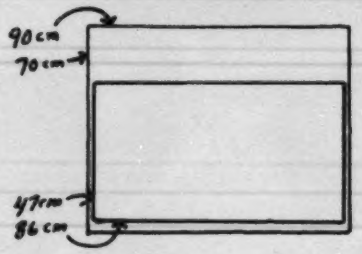


The group puts their measurements on a rough sketch of the playground.



☆ 5. *They Make the Scale Drawing.*

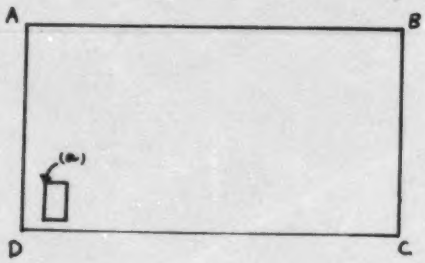
Bob and Charlie start the scale drawing by drawing lines for the length and width of the playground. To make sure that the corners between the lines are square, they use the corner of a pad of paper. They remember that their scale is 1 cm to 1 meter and make the lines the right length. Their drawing looks like this.



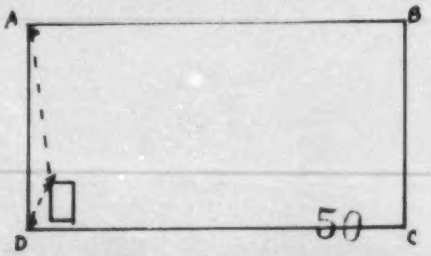
Now they wonder exactly where they should draw the swings, slides, monkey climb and baseball diamond on the scale drawing. "We'll have to make more measurements," says Joyce. "But I'm not sure what we should measure. Let's ask the teacher."

The teacher explains that in order to put swings and slides on the drawing they need to find the location of the spots on the playground where two corners of each equipment area are. "Then you can find the spots for the corners on the scale drawing and draw in the equipment," she says.

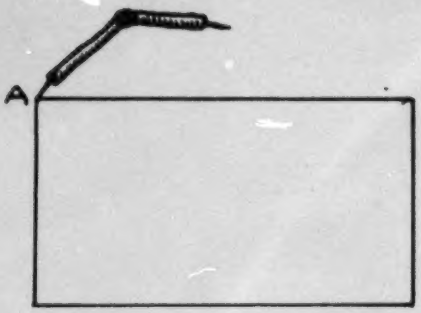
"To locate a spot on the playground you have to measure its distance from two corners of the playground," she adds. She draws a sketch of the playground on the chalkboard and labels the corners of the playground A, B, C, and D. She also labels one corner of the swing area with a small a.



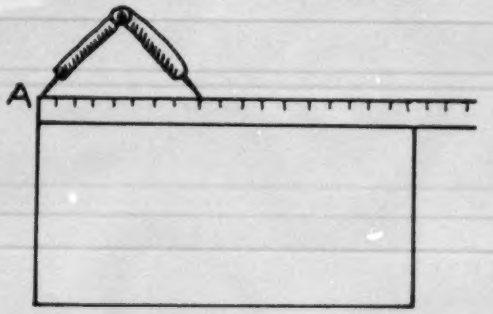
"To find point (a) of the swing area, you have to measure the distance from (a) to corner A and the distance from (a) to corner D," she tells them.



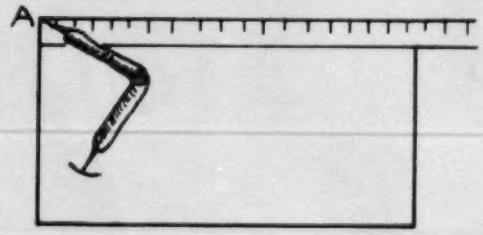
"Then you use a pencil compass to put point (a) from the swing area on your scale drawing," the teacher continues. "You put the metal point of the compass on corner A of the playground in the drawing.



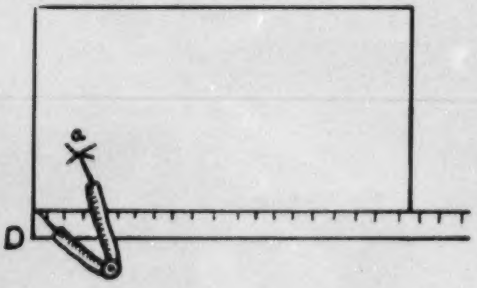
"You use your scale and stretch out the compass until the pencil point is the right distance from the metal point. The right distance is the number of spaces that stand for the measurement from (a) to A. You can put a ruler along the side of the scale drawing to make this measurement.



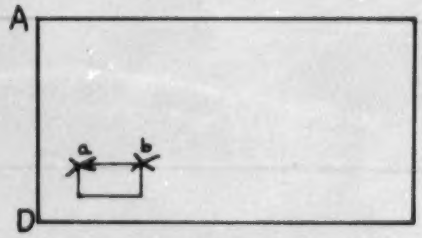
"Then you keep the distance between the two compass points the same, and draw an arc on the paper near where you think point (a) is located.



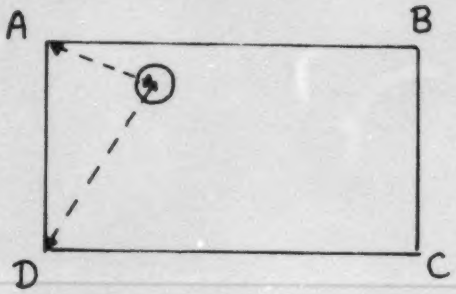
"Now you do the same thing with the distance from (a) to corner D. Point (a) is where the two arcs cross.



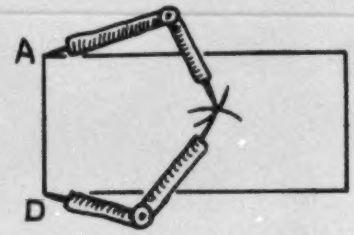
"After you have found another corner in the swing area, you can use your scale and the measurements you have made to draw in the area," the teacher says.



"To place the monkey climb on the scale drawing, you need to locate only one spot--the center of the circle," the teacher tells the students. "To do this you measure the distances from the center of the circle to two corners of the playground.

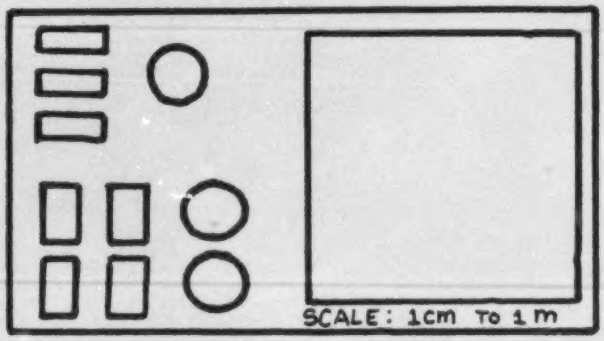


"You then use a pencil compass to find the spot on the scale drawing, and then draw a circle with the compass stretched out to half the length of the diameter of the circle," she says.



Charlie, Bob, Susan, and Joyce go over together what the teacher told them until they understand it. They then go out to the playground and measure from two of the playground corners to each spot that they want to locate. They put their measurements on their rough sketch.

When they are back in their classroom, they use pencil compasses to find the same spots on their scale drawing. They remember that their scale is 1 centimeter to 1 meter. Their scale drawing looks like this.



"There's lots of space between the monkey climbs and the ball field for other things," says Charlie. "We can put our tire climb there."

"We can put a tunnel between the slides and the swings," adds Joyce.

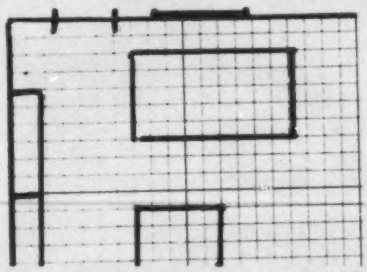
"Now we know where we can put other things," says Bob. "We can also figure out from the scale drawing how big we can make the tire climb and tunnel."

MAKING SCALE DRAWINGS SMALLER

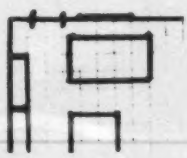
Sometimes you may have a large size scale drawing that you want to make smaller. It may be a scale drawing you have made, or a map you have obtained. You may want to make individual copies of the drawing or map that can be carried around easily.

You may have access to a copying machine that enlarges or reduces copy. If so, you can use the machine to make the scale drawings smaller.

You can, however, make scale drawings smaller yourself. Suppose you are using graph paper for your scale drawing. To make the scale drawing smaller, you can use graph paper with smaller spaces. You can also make the drawing smaller by changing the scale. Suppose your scale is 1 space to a meter. You can change the scale to 1 space to 2 meters. Then the drawing will be half as long and half as wide. The drawing will be one quarter the size of the original drawing. A section of the classroom scale drawing made in the first story is reduced by changing the scale. It looks like this.



SCALE: 1 SPACE TO 1 METER



SCALE: 1 SPACE TO 2 METERS

Suppose you are using plain paper for your scale drawing, and your scale is 1 centimeter to 1 meter. You can make your scale drawing one quarter as large by changing the scale to 1 centimeter to 2 meters. A section of the playground scale drawing shown in the second story is reduced by changing the scale. It looks like this.

SCALE: 1cm TO 1m

SCALE: 1cm TO 2m

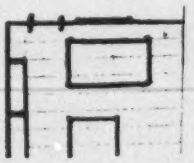
You may not have the data you used in making the original drawing. In that case, you can count the number of spaces or measure each distance on the original drawing. You then make each distance cover half as much space in your new drawing.

MAKING SCALE DRAWINGS BIGGER

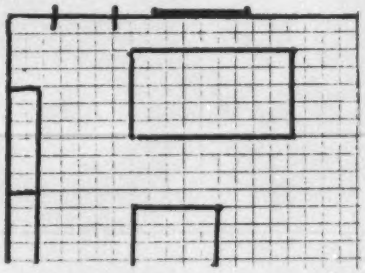
Sometimes you may want to make a scale drawing larger. Perhaps you have found a map of your community that is too small for your use. You may want to indicate students' houses or bicycle path routes on the map.

If you have access to a copying machine that enlarges copy, you can use it to make the scale drawing larger. You may also be able to project an image of the map on a screen. You put a large sheet of paper on the screen and trace the image onto the paper.

You can also make the scale drawing or map larger yourself. Suppose you are using graph paper for your scale drawing. You can make the drawing larger by using graph paper with larger spaces. You can also make the scale drawing larger by changing the scale. Suppose your scale is 1 space to 1 meter. You can change it to 2 spaces to 1 meter. Then a distance shown by 1 space in your original drawing would be shown by 2 spaces. Your scale drawing would be twice as wide and twice as long. Your scale drawing would be four times larger than the original drawing. A section of the classroom scale drawing is enlarged by changing the scale. It looks like this.



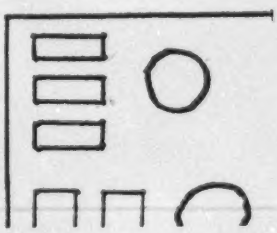
SCALE: 1 SPACE TO 1 METER



SCALE: 2 SPACES TO 1 METER

Suppose you are using plain paper for your scale drawing, and your scale is 1 centimeter to 1 meter. You can make the drawing four times larger by changing the scale to 2 centimeters to 1 meter, or 1 centimeter to 1/2 meter. A section of the playground scale drawing construction in the second story is enlarged by changing the scale. It looks like this.

SCALE: 1 cm TO 1 m



SCALE: 1 cm TO 0.5 m

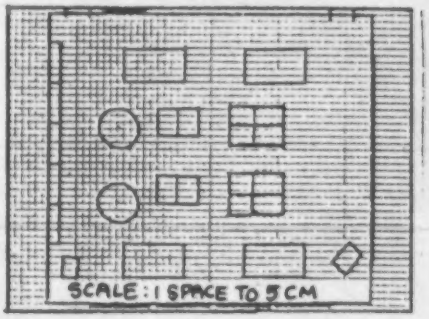
You may not have the data you used in making the original drawing. In that case, you can count the number of spaces or measure each distance on the original drawing or map. You then make each distance cover twice as much space in your new drawing.

HOW TO MAKE YOUR OWN SCALE DRAWING

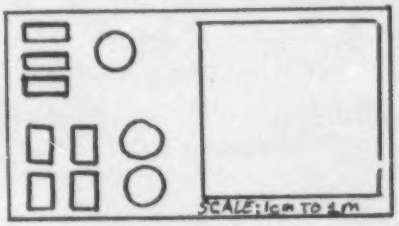
So far you have read about how students made scale drawings of their classroom and their playground. You may want to make a scale drawing of your lunchroom, or something else. This checklist will help you make your own scale drawing.

☆ 1. DECIDE HOW TO MAKE THE SCALE DRAWING

- You can use graph paper if most of the sides of the area meet at square corners and the area is not too big for the graph paper. (You can tape several sheets of graph paper together.)

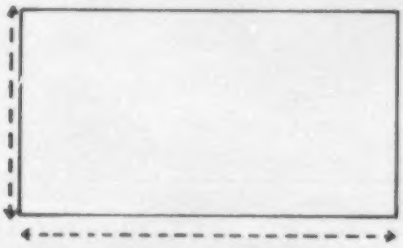


- You can use plain paper if the area is large, or if two or more of the sides don't meet at square corners.



☆ 2. DECIDE ON A SCALE

- Measure the length and width of a rectangular area.



- If you are using graph paper, divide your measurement of the longest side of the area by the number of spaces on the longest side of the graph paper. A number that ends in 0, 2, or 5 that is more than your answer will give you a scale that is easy to use. It is the distance that can be shown on 1 space.

$\frac{96\text{ cm}}{12\text{ spaces}} = 8.0\text{ cm per space}$

8.0 cm per space → 10 cm per space

SCALE: 1 space to 10 cm

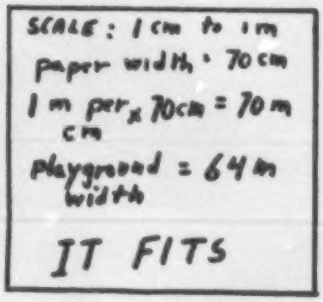
- If you are using plain paper, divide your measurement of the longest side of the area by the length of the longest side of the paper. A number that ends in 0, 2, or 5 that is more than your answer will give you a scale that is easy to use. It is the distance that can be shown on 1 unit of length of your paper.

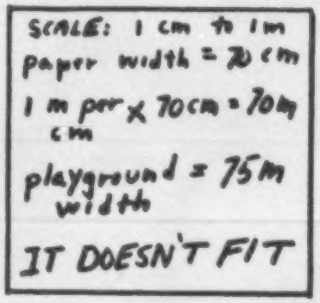
$\frac{85.30\text{ m}}{90\text{ cm}} = .94\text{ m per cm}$

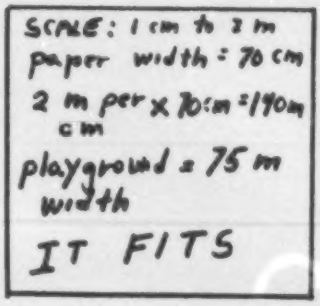
.94 m per cm → 1 m per cm

SCALE: 1 cm to 1 m

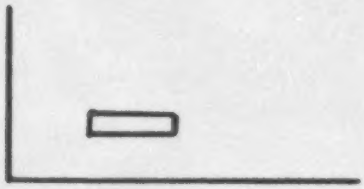
- Check your scale by seeing whether the width of the area will fit on the wide side of your paper. If it doesn't fit, use a smaller scale. Instead of 1 centimeter to 1 meter, for example, use .5 centimeters to 1 meter, or 1 centimeter to 2 meters.

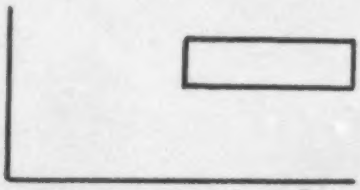






- Check your scale by seeing whether something small that you want to put on your scale drawing will be too hard to see. If so, use a larger scale. Instead of 1 centimeter to 1 meter, for example, use 1 centimeter to .5 meter.

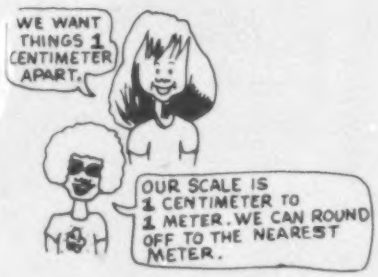




☆ 3. DECIDE HOW ACCURATE YOUR MEASUREMENTS NEED TO BE

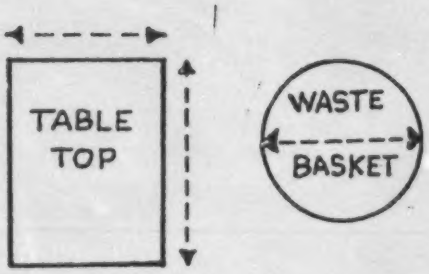
- If you are using graph paper, decide whether you want things closer than 1 space on your scale drawing. If not, your measurements can be rounded off to the distance shown in one space.

- If you are using plain paper, decide how close you want things to be on the paper. You can then round off your measurements to that distance.

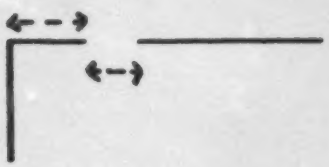


☆ 4. MAKE YOUR MEASUREMENTS

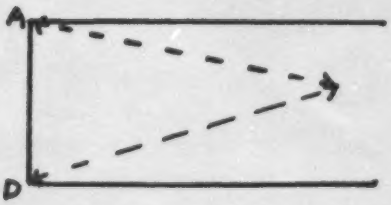
- Measure everything you want to put on your scale drawing. If it is rectangular, you measure its length and width. If it is round, you measure its diameter.



- Measure where the doors, windows, gates, or other things along the sides are.

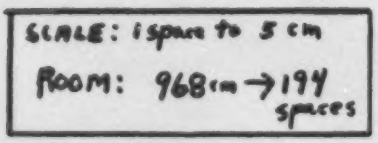


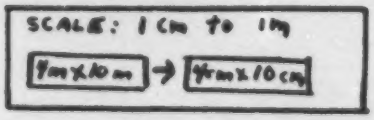
- If you need to locate certain points in the area, measure the distance from that point to two corners of the area.



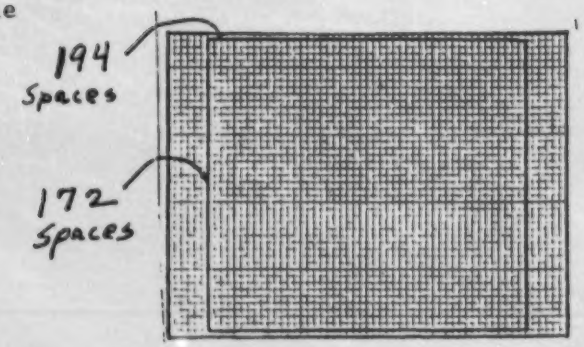
☆ 5. MAKE THE SCALE DRAWING

- Use your scale and change your measurements to spaces or distances on your paper.

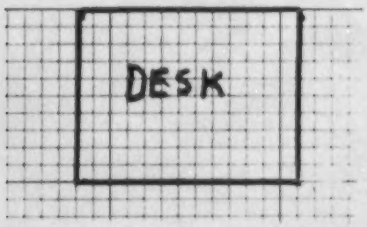




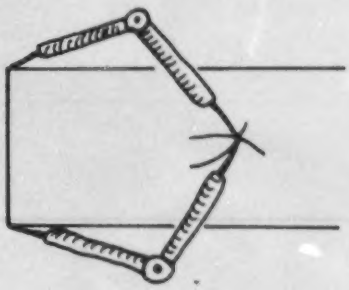
- Draw the sides of the area on your scale drawing.



- If you are moving furniture around, make cutouts for each piece of furniture.



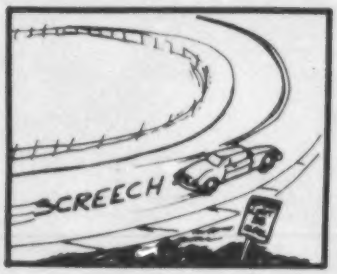
- If you need to find certain spots on the scale drawing, use a pencil compass and your measurements to two corners of the area.



"HOW TO"

FIND THE SPEED OF THINGS

DO YOU NEED TO FIND OUT HOW FAST SOMETHING IS MOVING?

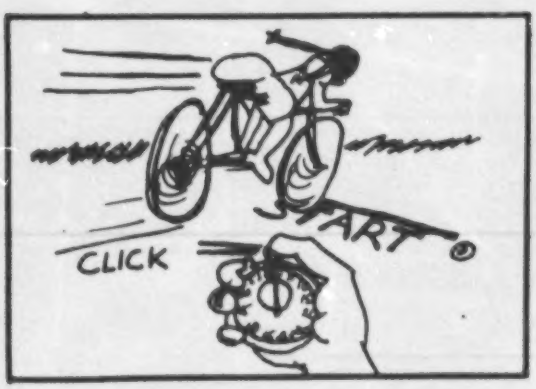


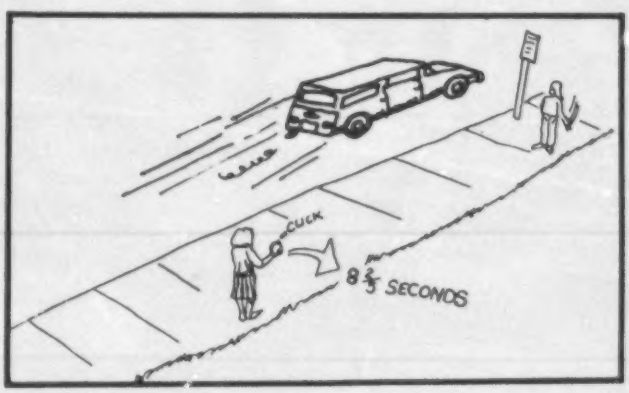
Suppose you are worried that cars on your street go too fast. Maybe you think that a lot of cars go faster than the speed limit.

To find out, you will need to measure the speed of cars on your street. Then you will know how fast they are really going.

You might also want to find the speed of other things, such as bicycles, animals, or people running.

Inside you will find out how speed is different from other measurements. You will also find out how to measure the speed of bicycles and cars.





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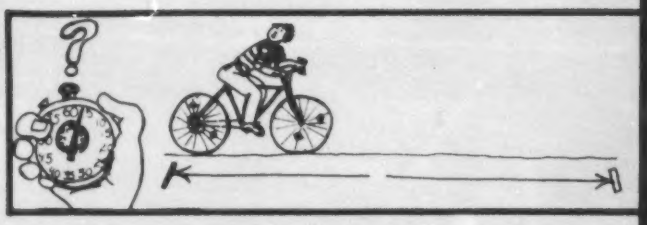
SOME THINGS TO KNOW BEFORE YOU MEASURE SPEED

When you measure time, you need to know how long something takes.



When you measure distance, you need to know how far something is.

When you measure speed, you need to know how long something takes to go a certain distance and how far that distance is.

You need to make two measurements. You need to measure distance. And you need to measure time.

When you have found the distance and the time, then you can find the speed. You can find out how fast something is moving.

Here's how.

$$\text{SPEED} = \frac{\text{DISTANCE}}{\text{TIME}}$$

Now you are ready to learn how to measure speed.

FOUR STEPS FOR MEASURING SPEED

When you want to measure speed, follow these four steps:

1. MEASURE THE DISTANCE.
2. MEASURE THE TIME.
3. CALCULATE THE SPEED.
4. CHECK YOUR UNITS OF MEASUREMENT AND CHANGE ANY THAT YOU NEED TO.

MEASURING THE SPEED OF BICYCLES

Suppose your class wants to take a long bicycle trip. You might want to know how fast everyone will be riding so you can figure out how long the trip will take. You can measure the riding speed for each person. Here's what you do.

1. *Measure the Distance.*

Choose a distance to measure. You can pick a good place along a bicycle path or a sidewalk. Make sure you can see pretty far down the path. Make sure there aren't a lot of trees or signs or people in the way. Make sure the distance is not too short. It should be 50 meters or longer.

Suppose you decide to measure 50 meters. Use a long tape measure to make your measurement. Stretch out the tape measure along the path or sidewalk. You will need two people to do this.

Mark a line on the ground next to the 0 mark on the tape measure. Use tape or chalk to make the line. This line is your starting point.

Mark a line on the ground next to the 50-meter mark. This line is your stopping point.

2. *Measure the Time.*

Before you measure the time, you will need to get ready. You will need a stopwatch. (Make sure you read "How To" Use a Stopwatch.) You will also need two people to do the measuring.

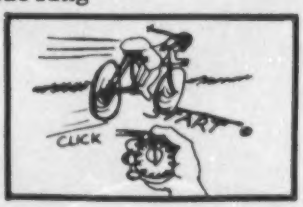
Have one person stand near the starting point. This person will time with the stopwatch.

Have another person stand near the stopping point. This person will signal with his hand when the rider passes the stopping point.

Now you are ready to measure riding time.

Suppose you are starting with Joanne. Have her get on the bicycle several meters before the starting point. You want to know her usual riding speed, so she shouldn't ride too fast. She should ride as if she were taking a long trip.

The person timing with a stopwatch must watch carefully. When Joanne crosses the starting point, he starts the stopwatch.



Joanne keeps riding. She rides several meters past the stopping point. The person near the stopping point must watch carefully. When Joanne crosses the stopping point, he signals right away. When the timer sees the signal, he stops the stopwatch right away.

Read the stopwatch and write down Joanne's time.

Now you can time other people. Make sure you do it the same way each time.

3. *Calculate the Speed.*

Suppose Joanne's time is 7 1/5 seconds. That is the same as 7.2 seconds. And you know that she rode 50.0 meters. Here's how to figure her speed.

Remember: $\text{Speed} = \frac{\text{Distance}}{\text{Time}} = \frac{50.0 \text{ meters}}{7.2 \text{ seconds}}$

Do the division.

$$7.2 \text{ seconds} \overline{)50.000 \text{ meters}} \quad 6.94 \text{ meters/second}$$

$$\begin{array}{r} 432 \\ \hline 680 \\ 648 \\ \hline 320 \\ 288 \\ \hline 32 \end{array}$$

You can see that your answer will not come out evenly. Even if you carry out the division to many places, it is a repeating decimal--6.9444...--and will never come out evenly. So what do you do?

Keep only two figures.

Here, both the time and the distance have only two digits. That means that you can actually keep only the first two digits in the speed; so you write 6.9 meters per second. This means that Joanne's speed is about 6.9 meters per second.

(You will find out more about how many figures to keep for your speed measurements in the last section.)

4. *Check Your Unit of Measurement and Change It if You Need To.*

You measured the speed of a bicycle in meters per second. But suppose you need to use speed measurements to find out how long it will take your class to ride on a class trip. You found the distance in miles from a map. You may want to know the time in hours. You can convert your speed measurements from meters per second to miles per hour.

You will find out much more about this in the story that follows.

MEASURING THE SPEED OF CARS

Jessica's class is working on a pedestrian safety problem. The children think that a street near the school is unsafe. They are worried that cars go too fast down Zoom Street. They think someone might get hurt. Jessica, David, Eric, and Helen are supposed to find out how fast the cars on Zoom Street are going. They want to find out how many cars are going faster than the speed limit.

David and Helen know what to do. "We have to measure the speed of cars," David says. "I learned how to measure the speed of bicycles last year. I guess you do pretty much the same thing for cars."

"I worked on bike speeds, too," says Helen. "We asked kids to ride their bikes. Then we found out how much time it took them to ride a certain distance. We divided to find the speed."

Eric laughs. "Well, we can't ask the cars to speed for us. We'll have to measure them without asking."

"Anyway, let's get going," Jessica says. "What do we do first?"

"The first thing is easy," says Helen. "We have to find a place to measure speed. Naturally, it has to be along Zoom Street. "Let's go out there.

The four children go out to look at Zoom Street.

"There are an awful lot of signs and billboards and stuff," says David. "How are we ever going to get a good view?"

"We'll have to do the best we can," Eric replies. "We can't pick another street. I guess right here between Popsicle World and Greazy's is the best place."

"Okay. Tomorrow we can bring the tape measure and the stopwatch and start measuring."

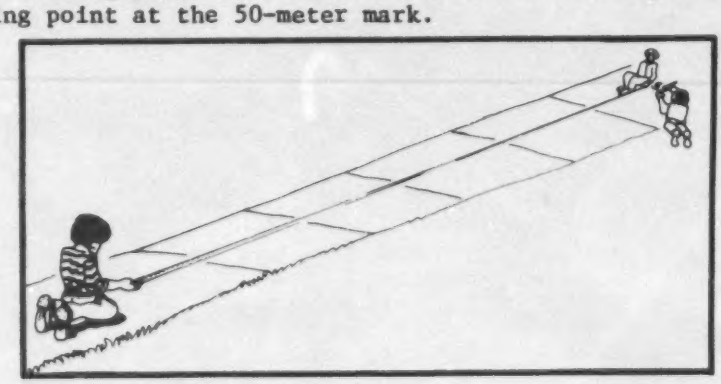
They Measure the Distance.

The next day the children go back to Zoom Street. They bring a 50-meter tape measure and a stopwatch.

"Let's see," David says. "When we worked on bicycle speeds we measured a distance of 50 meters. I guess we can do that now."

"Let's mark the distance on the sidewalk. It's safer than being in the street. I brought a piece of purple chalk, so we'll be able to see our lines well enough," Helen says.

Helen and Eric stretch out the tape measure along the sidewalk. David marks the starting point next to the zero end of the tape measure. He marks the stopping point at the 50-meter mark.



They Measure the Time.

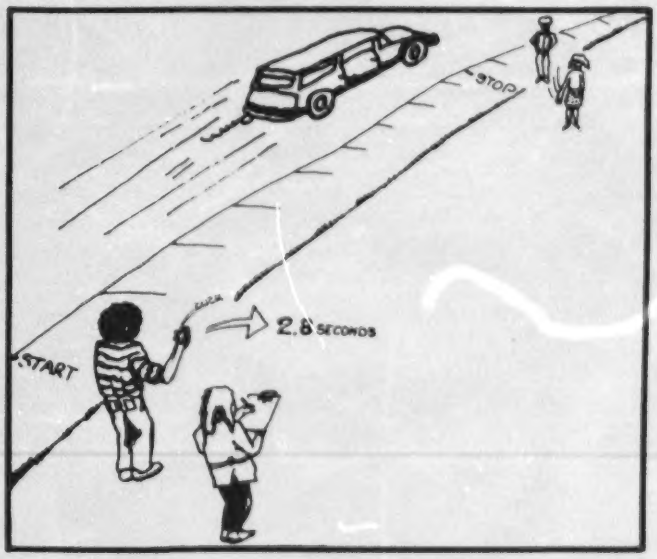
"Okay. Ready to go. Who wants to time with the stopwatch?"

"I will," Jessica answers. "I haven't done anything yet today. Where do I stand?"

Helen explains how she and David timed bicycles. "You stand near the starting point and start the stopwatch when a car passes that point. I'll stand near the stopping point and signal when the car passes," she says. "Watch for my signal to stop the stopwatch. Are we ready?"

"I'll write down the time," Eric says. "Let's practice with the first station wagon that comes after we're ready."

Jessica gets ready. She starts the stopwatch when she sees the first station wagon pass the starting point. She watches for Helen's signal. She stops the stopwatch as soon as she sees Helen drop her hand.



"Wow, was that car going fast!" David exclaims. "What does the stopwatch say?"

"Two and four-fifths seconds. But I barely had it going before I had to stop it. It all happened so fast I'm not sure it's right," Jessica complains.

"That's too short a time," Eric says. "We need to make our times longer. We can do that by making the distance longer."

"What?" says Jessica.

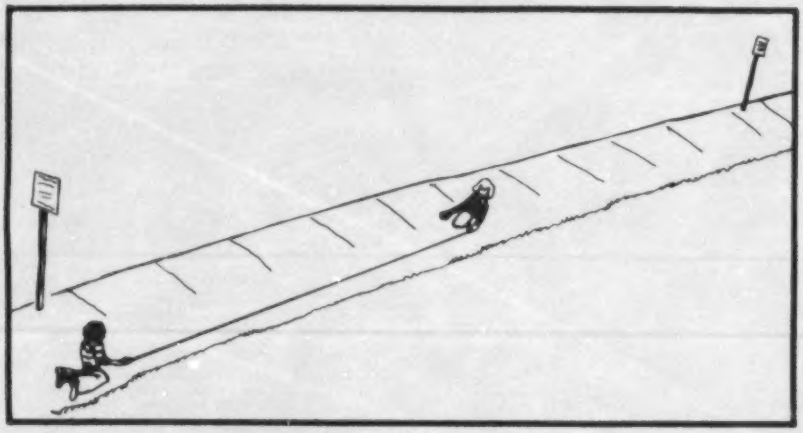
"Yes," David says. "I remember now. Fifty meters was all right for bicycles, but we'll need a longer distance for cars. If we make the distance 100 meters instead of 50 meters, the time would probably be at least five seconds. It's easier to be accurate when you're timing something for five seconds. Two or three seconds is just too short."

"I guess we need to measure all over again," Jessica says.

They Measure the Distance Again.

The children measure the distance again. They stretch out their tape measure the same way as before. Then they notice two sign posts along the street. These posts are about 100 meters apart. The four children decide to use these posts as starting and stopping points when they time the cars. It will be easy to see when a car passes each post.

David and Jessica measure the distance between the posts. The distance is longer than the tape measure. They have to move it twice to get their measurement.



They measure the distance three times and then take the median of their measurements. It is 110.6 meters.

They Measure the Time Again.

Now the children are ready to time cars again. But this time there is a different problem. Jessica is standing near the starting point with the stopwatch. And Helen is standing near the stopping point. But Jessica cannot see Helen very well.

"You're too far away," Jessica shouts. "I'll never be able to see your hand signal!"

"We'll have to try something different!" David shouts. "Come on back here."

So the four children talk over this new problem. Eric has an idea. "Jessica, why don't you stand in the middle? I'll stand at the starting point. Then you can watch for my signal to start the stopwatch. And you can watch for Helen's signal to stop the stopwatch."

"It should work," Jessica agrees. "I'll only be about 50 meters from each of you. I should be able to see your signals."

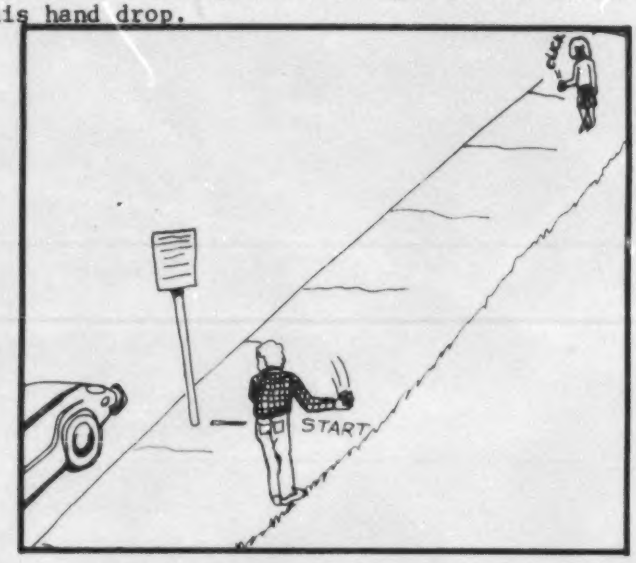
They try it out. Jessica can see both Eric and Helen very well when she stands about half-way between them.

Jessica is ready to time a car. But now Helen has a problem. "Sometimes a lot of cars come at once," she says. "How do we know if Eric and I are watching the same car?"

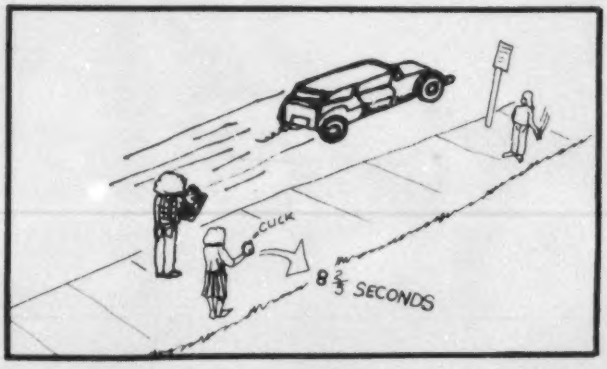
This time Jessica has an idea. "You could count cars that go by and just time every fifth car."

"That's right," says Eric, "we can start with the next station wagon."

Everyone gets in place. Eric stands at the starting point. He watches for a station wagon. When a station wagon passes the post, he drops his hand. Jessica is watching for his signal. She starts the stopwatch when she sees his hand drop.



Then Jessica watches Helen. Helen has also been watching for the station wagon. When it passes, she drops her hand. Jessica sees her signal and stops the stopwatch. Then she reads the time on the stopwatch to David. David writes it down on a data chart.



They time 10 cars in this way. When they are finished, David's data chart looks like this.

CAR TIMES - ZOOM STREET MAR. 3

CAR	TIME (sec)
1	8 2/5
2	7 1/5
3	9 3/5
4	8
5	9 4/5
6	10 4/5
7	11 3/5
8	9 1/5
9	6 1/5
10	7

"These times are O.K.," David says. "They aren't too short. We're ready to do our calculations."

They Calculate The Speed.

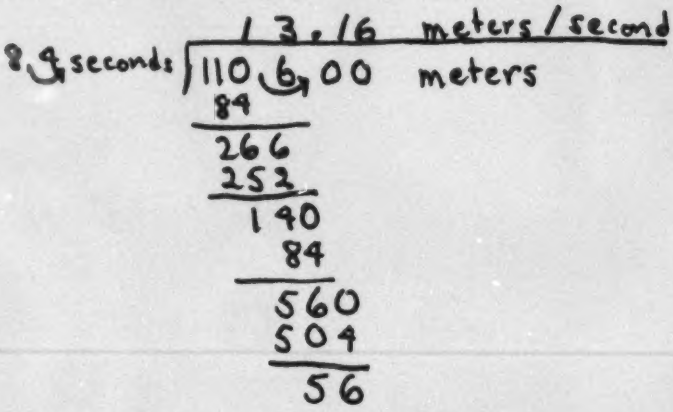
Next day the four children meet to calculate the speeds. They look at their data chart from the day before.

"All we have to do is divide the distance by the time," David says. "The distance is the same for all the cars. It's 110.6 meters."

"The first car took 8 2/5 seconds," Jessica says. "Ugh! We have to divide that into 110.6 meters!"

"It's easy to change 8 2/5 seconds to 8.4 seconds. We can change all our times before we divide," Helen says.

The children do the division. They get this far.



Then Jessica says, "Say, how far do we have to carry this out, anyway? We already have two decimal places. Our answer could go on forever."

"I don't know," David admits. "Let's ask Ms. Bernstein."

"Your answer should have the same number of digits or figures as the measurement with the fewest digits," the teacher says. "What are the two measurements?"

"The distance is 110.6 meters and the time is 8.4 seconds."

"The distance has four digits, but the time has only two," the teacher says.

"I guess our answer should have only two digits," says Jessica. "This means we should write the speed as 13 meters per second." The other children agree.

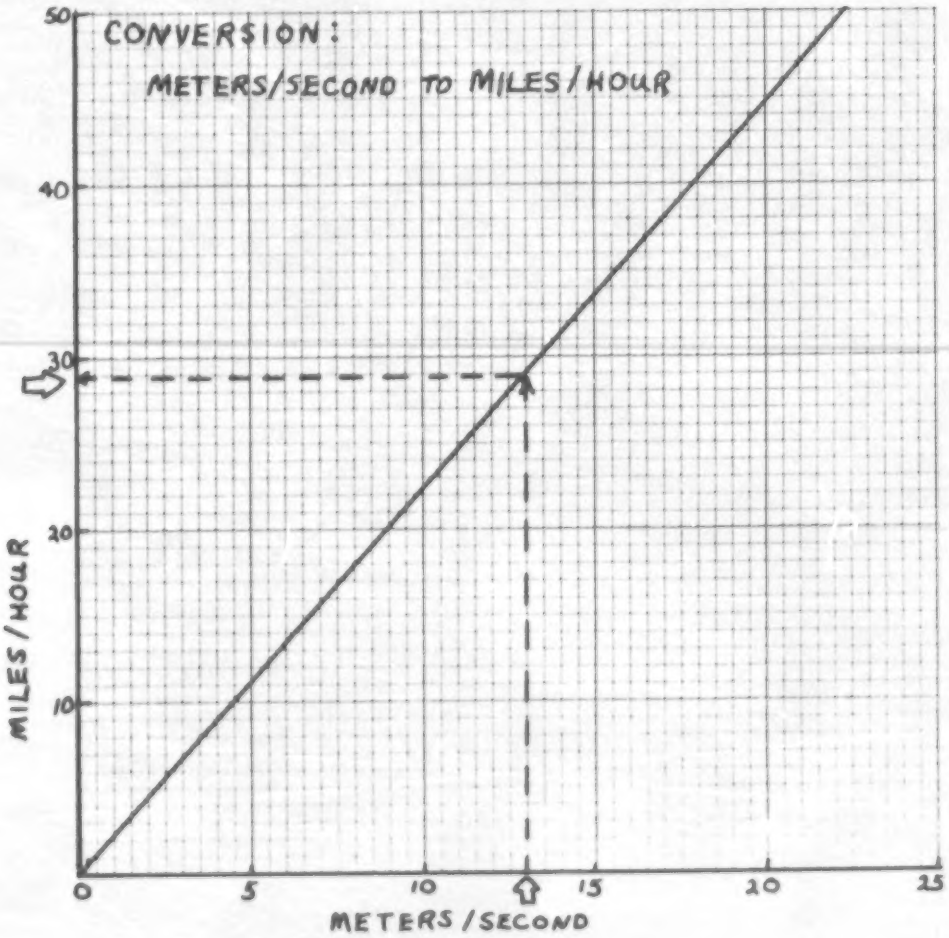
They divide to find the other nine car speeds. They check their answers carefully to make sure they are right.

They Check Their Unit of Measurement and Change It.

"Well, here are our answers. But they won't do us much good. We can't tell how many cars are speeding. Our answers are in meters per second, and the speed limit is 25 miles per hour!" Eric moans.

"I think we can convert them to miles per hour, but we'd better ask Ms. Bernstein. I don't know how to do it," Helen says.

Ms. Bernstein tells them that they can make a graph to convert miles per second to miles per hour. She suggests that they read "How To" Make a Conversion Graph. This booklet helps them make a conversion graph. They make one like the one below. This graph has meters per second on the bottom and miles per hour on the side. The children find the first speed, 13 meters per second, on the bottom. Then they draw a straight line to the diagonal line on the graph. Then they draw another line to the side. They read the speed in miles per hour on the side.



Remembering that there are only two digits in the time measurement, Jessica says, "We should write the speed in miles per hour only with two figures."

"That means we can say that the first car was going about 29 miles per hour," responds Helen. "That's good enough to tell us that car was going over the speed limit!"

The four children use the conversion graph to change the rest of their speeds to miles per hour. Then they look at the numbers.

"The speed limit is 25 miles per hour," Helen says. "Seven out of ten cars were going faster than that. I think we should recommend that the police do a better job. Maybe warning signs would help."

"Yes," says David, "but first I think we should measure the speeds of cars for a week between eight and eight-thirty in the morning. That's when kids have to cross this street. We should find out whether a lot of cars speed in the morning."

The other children groan. "Not all over again!"

"It won't take that long," David says. "We know how to do everything now!"

MAKING YOUR OWN SPEED MEASUREMENTS

So far you have read about how to measure the speed of bicycles. And you have read a story about measuring the speed of cars. You may need to find the speed of something else--like a person or an animal. Or you may need to measure a little differently from the two ways you have read about. This checklist will help you make your own speed measurements.

1. MEASURE THE DISTANCE.

   - Make sure you have a good view of what you are measuring.
   - Decide how far you want to measure.
   - Mark a starting point.
   - Measure the distance from the starting point.
   - Mark the point where your measurement ends.

2. MEASURE THE TIME.

   - Use a stopwatch to measure how long it takes something to go between your starting point and your stopping point.
   - Is your time too short, say 2 or 3 seconds? If so, go back and measure a longer distance. Then measure the time again. Measure the same way each time.

3. CALCULATE THE SPEED.

   - Divide the distance by the time to find the speed. Remember to keep only as many figures are in the <u>less</u> accurate of your measurements.

4. CHECK YOUR UNITS OF MEASUREMENT AND CHANGE ANY THAT YOU NEED TO.

   - Do your speed measurements tell you what you want to know? If not, you may need to convert your measurements from one unit to another. (You might need to convert your measurements from meters per second to miles per hour.)

HOW CLOSE CAN YOU MEASURE?

When you measure speed, you are making two measurements. You are measuring the distance something goes. And you are measuring the time it takes. You try to be accurate when you make both measurements. But sometimes things happen that make your measurements not exact. These things are called errors.

Here are some errors that might happen when you measure speed.

This error might happen when you measure distance.

- Your measurement might not be exact when you measure with your tape measure. The distance might be a little more or a little less.

These errors might happen when you measure time.

- Your stopwatch might not be exact. The time might really be a little more or a little less than it measures.
- You might start timing a little too soon or a little too late. Or you might stop timing a little too soon or a little too late.

  You may be using hand signals when you time something. If so, the person signalling may drop his or her hand a little bit after a car passes the starting point. The person timing may start the stopwatch a little bit after he sees the hand signal. Then you would have two errors. This would make your time even less accurate. This could happen when you stop timing, too.

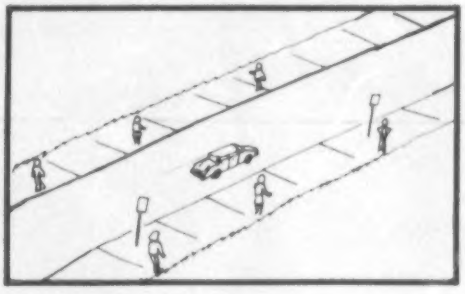
What to do about errors

You can't avoid errors. But here are some things you can do to help make your measurements more accurate.

1. *Repeat Your Measurements When You Can.*

   Measure the distance several times. Then take the median of your measurements. You can't repeat your time measurements. But you can have two or more teams timing at the same time.

   Suppose you have two teams timing cars to find out their speeds. You would have to make sure that everything is the same for both teams. Each team must use the same type of stopwatch. They must time cars at the same place over the same distance. And you would have to make sure the teams time the same cars. You would have to be careful to keep the two teams separate so that they don't get mixed up.

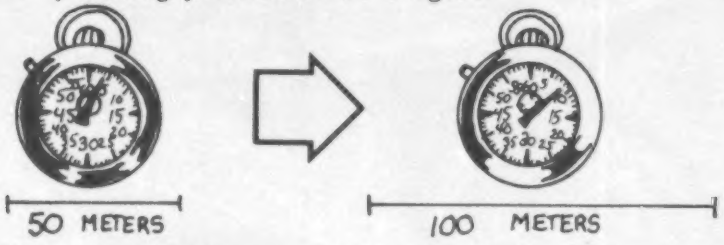


   Then you would have two sets of time measurements. You would need to figure the average time before you find the speed.

2. *Make Sure Your Times Are Not Too Small.*

You can be more accurate with longer times than with shorter times. When your times are 2 or 3 or 4 seconds, errors will matter a lot. Try to make your times 5 or 6 seconds or even more.

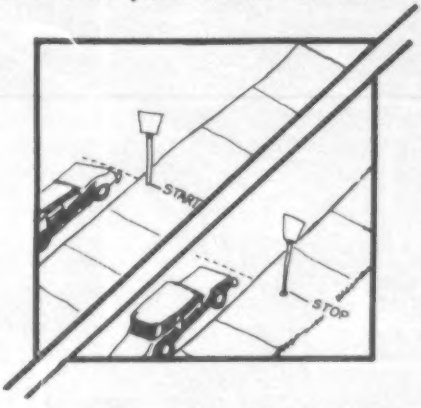
You can do this by making your distance longer.



You will have to make a trial measurement to find out if your times are too short.

3. *Measure All the Times the Same Way.*

Are you timing cars? You may want to start the stopwatch when the front bumper of the car passes the starting point. Or maybe when the front or the rear wheel of the car passes the starting point. Whichever way you measure, do it the same way for the rest of the cars. Stop the stopwatch the same way, too.



4. *Don't Round Off Your Time Measurements.*

Make your time measurements as accurately as you can. Your time measurement will probably be less accurate than your distance measurement. Stopwatches have small marks for fifths or tenths of seconds. Read the time you measure to the nearest fifth or tenth of a second. This will make your speed measurement more accurate.

5. *Use Only the Number of Digits for Speed that Are in the Measurement with the Fewer Digits.*

This will help you when you divide to find speed. Don't try to make your speed measurements more accurate than either the time or the distance measurements. Suppose your distance is 94 meters and 21 centimeters. That's 94.21 meters. And suppose the time is 9.4 seconds. The distance measurement has <u>four</u> digits in it. But the time measurement has only two digits in it. That means that the speed can have only two digits in it. The speed is

$$\text{Speed} = \frac{94.21 \text{ meters}}{9.4 \text{ seconds}} = \frac{10 \text{ meters}}{\text{second}} .$$